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AN EXAMINATION OF THE ROLE OF ECONOMETRIC MODELS AND MANAGEMENT INPUTS IN BID PRICE DETERMINATION IN CLOSED COMPETITIVE BIDDING SITUATIONS WITH REFERENCE TO THE CANADIAN CONSTRUCTION INDUSTRY

by

BRUCE ARNASON ©

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
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EDMONTON, ALBERTA

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled, "An Examination of the Role of Econometric Models and Management Inputs in Bid Price Determination in Closed Competitive Bidding Situations with Reference to the Canadian Construction Industry," submitted by Bruce Arnason in partial fulfilment of the requirements for the degree of Master of Business Administration.

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Date September 3, 1975

ABSTRACT

The problem of competitive bid price determination is examined within the context of the construction industry with the objective of providing a comprehensive framework within which the study of bidding situations can proceed.

The background is first established, then the complexity of corporate objectives and strategy considerations is examined. The literature is reviewed to see to what extent it contemplates the many and varied objectives and strategy considerations and is found to be deficient in this regard.

Modifications to the major works that may better consider the complex dimensions of competitive bidding situations are suggested. In addition, a new, more comprehensive way of analyzing bidding situations is set forth.

The limitations of econometric tools and the role of management in bid price decisions are then discussed. Finally, directions for future research and potentially beneficial research tools are outlined.

The methodology throughout is analytical and normative.

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CHAPTER I

INTRODUCTION

This thesis presents an analytical study of competitive bidding in the Canadian construction industry. An exhaustive search of the literature and subsequent study of the available published material pointed out the need for much study and research on the topic of competitive bidding. Of the little research and publishing that has been done, much of it is repetitive or mere paraphrasing of the work of a few legitimate researchers. Virtually no research has been done in Canada. No books have ever been published on competitive bidding--the literature consisting of approximately two hundred articles, some dissertations and a very few internal reports of large companies. Study in this area is so much in its infancy that there are no clearly distinguishable schools of thought or even approaches of study by which the existing literature can be categorized.

Competitive bidding is used in many economic situations other than the construction industry as, for example, in the supply of industrial materials, in the letting of government rights for oil and mineral exploration and in the purchase of properties. The construction industry was chosen for consideration because it is the most complex situation, having the largest number of variables affecting bid price determination. Findings relevant to the construction competitive bidding situation are likely to be relevant to other bidding situations whereas the reverse may not be true.

The purpose of this thesis is to assist future researchers by:

(1) Setting out, in one volume, a complex bidding situation.

(2) Identifying some of the necessary strategy considerations.

(3) Reviewing the worthwhile research that has been done.

(4) Clarifying what the bidding problem is and suggesting approaches to win probability determination that better encompass strategy considerations.

(5) Pointing out the limitations of econometric win probability and bid price determination models.

(6) Analyzing the role of managerial inputs into the bid price determination.

(7) Pointing out directions for future research and potentially beneficial tools for research in this area.

(8) Providing a comprehensive bibliography of published resource material on competitive bidding.

To accomplish these aims the thesis has been divided into seven chapters.

Chapter II is a background chapter describing the nature of the industry and the bidding process. It describes the characterization of the construction industry within the Canadian economy, the characteristics of the industry, such as concentration, entry and exit and relation to government policy. The financial characteristics of contracting firms are discussed and analyzed on the basis of statistical data compiled from information collected by Statistics Canada. Comparative balance sheets and income statements are presented and analyzed. Attention is then turned to a description of what a contract is and how it is acquired, i.e., the bidding process and procedures.

Chapter III discusses the strategy of bidding, outlining what needs to be accomplished in bidding (from the contractor's point of view) and what factors are likely to affect the attainment of this objective.

Chapter IV reviews the literature on a selective basis. Only the works with distinct contributions or approaches are considered. Much of the literature consists of mere modifications of various original ideas.

Chapter V examines, in detail, the two major works on competitive bidding. Friedman's original work (1956) and Broemser's approach (1968) are related in terms of win probability calculations. Modifications to these approaches, to better encompass strategy considerations, are suggested. The scope and role of econometric prediction models are then discussed.

Chapter VI outlines the author's conception of the management role in bid price determination.

Chapter VII sets forth directions for future research.

Appendix "A" relates to Chapter II and provides details of definitions and inclusions or exclusions from items listed in the statistical tables or used in compilation of graphs and charts in that chapter.

The Bibliography lists approximately two hundred sources of published material on competitive bidding.

CHAPTER II

THE NATURE OF THE INDUSTRY AND THE BIDDING PROCESS

Introduction

To understand the intricacies of closed[1] competitive bidding in the fifteen to eighteen billion dollar Canadian construction industry, it is necessary to be familiar with some of its most important characteristics. This chapter will detail the types of construction that use competitive bidding, the importance of this activity to the Canadian economy, the characteristics of the industry, the nature of contracts, and the characteristics of contractors, and it will describe what is involved in the bidding procedure.

The Data Sources and Methods

This chapter contains an analysis of construction in Canada with particular emphasis on the construction industry. The tables, graphs and other statistics included have been constructed from basic statistical data published by Statistics Canada. The publications used are (1) Corporation Financial Statistics and (2) Construction in Canada.

To facilitate the interpretation of the data in this chapter the relevant definitions and statistical sources and methods notes are included as Appendix "A".

---

[1] Closed competitive bidding is where bids are submitted in sealed envelopes and the bidding is done only once.

Characterization of the Industry in the Economy

There are essentially two types of construction: contract construction and force account construction. Force account construction is work done by an owner's "own forces" rather than "let" via competitive bid to a professional contractor and hence is of little importance to this study. Contract construction, however, comprises over 80 percent of total construction and is almost always let via competitive bid.[2]

Figure 1 presents a bar graph of total construction activity in Canada as percentages of Gross National Expenditure for the years 1964-1972. The total current dollar value as a percentage of G.N.E. has remained consistently in the 16-18 percent range; however, total current dollar value as a percentage of G.N.E. in terms of constant 1961 dollars has slowly but steadily fallen from 17.1% in 1964 to 15.2% in 1972. This would seem to indicate that the real importance of construction activity to the Canadian economy is lessening as manufacturing and service industries become more developed, but that this trend is disguised by a more rapid rate of inflation in the construction industry than in the economy as a whole. As Canada becomes more of a producing nation its construction activity as a percentage of Gross National Expenditure should approach the U.S. level of approximately 10%.

---

[2] Some contract construction is negotiated but most owners prefer the bidding process.

FIGURE 1

TOTAL CONSTRUCTION IN CANADA 1964-1972
AS % OF G.N.E. IN CURRENT
AND CONSTANT (1961) DOLLARS

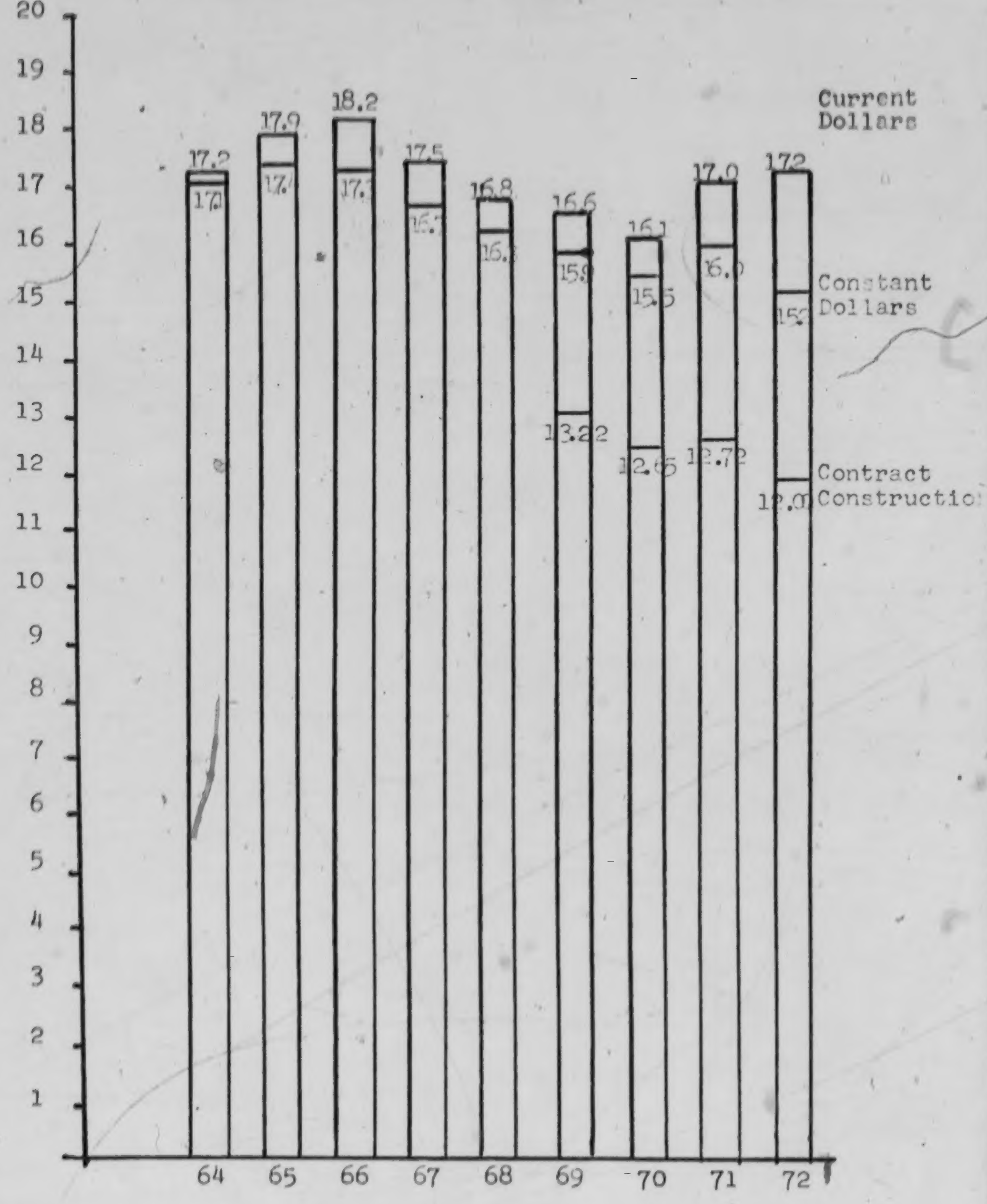


FIGURE 2

TOTAL VALUE OF CONSTRUCTION WORK PERFORMED IN CANADA
BY NEW AND REPAIR 1964-1973
IN CURRENT AND CONSTANT (1961) DOLLARS

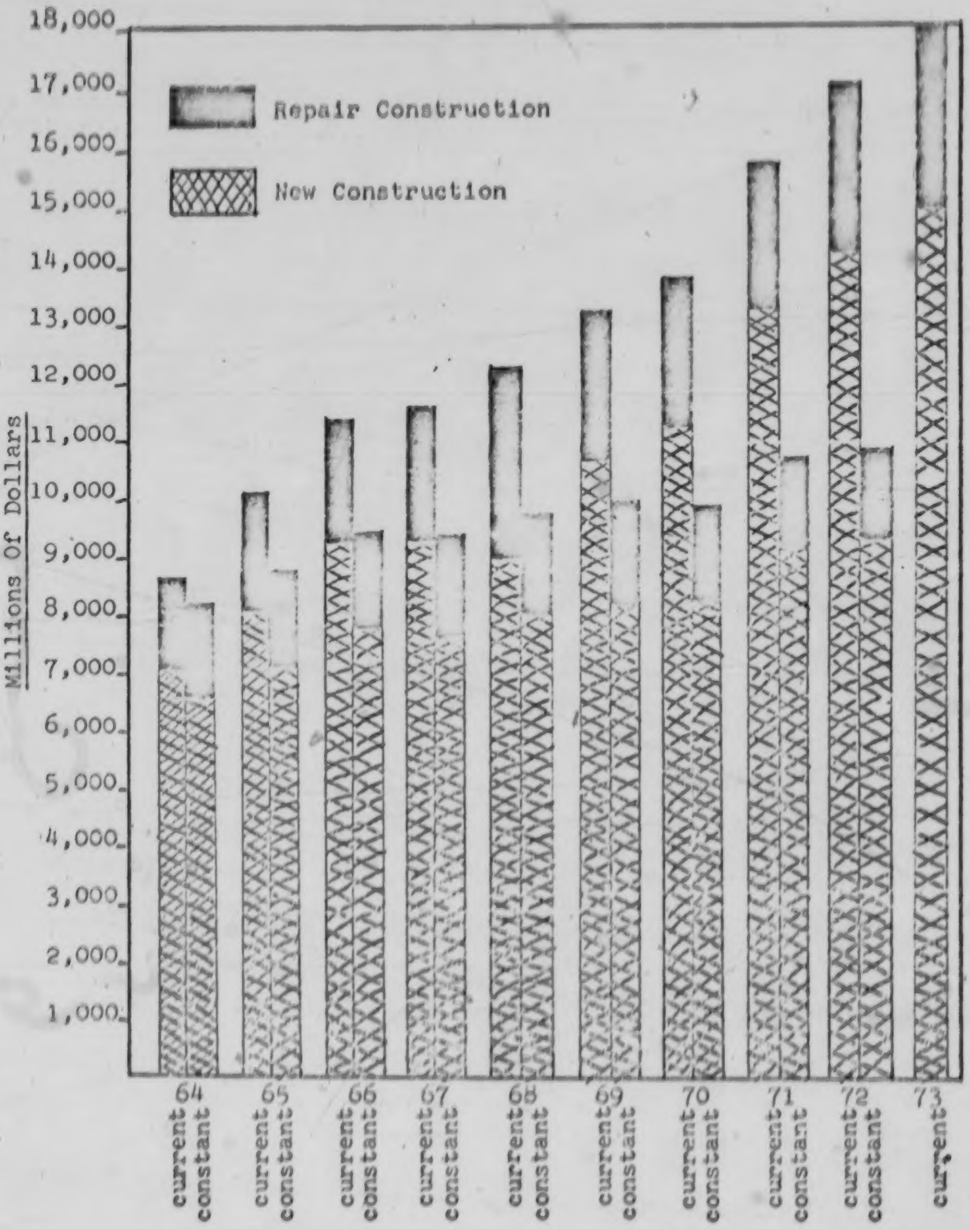
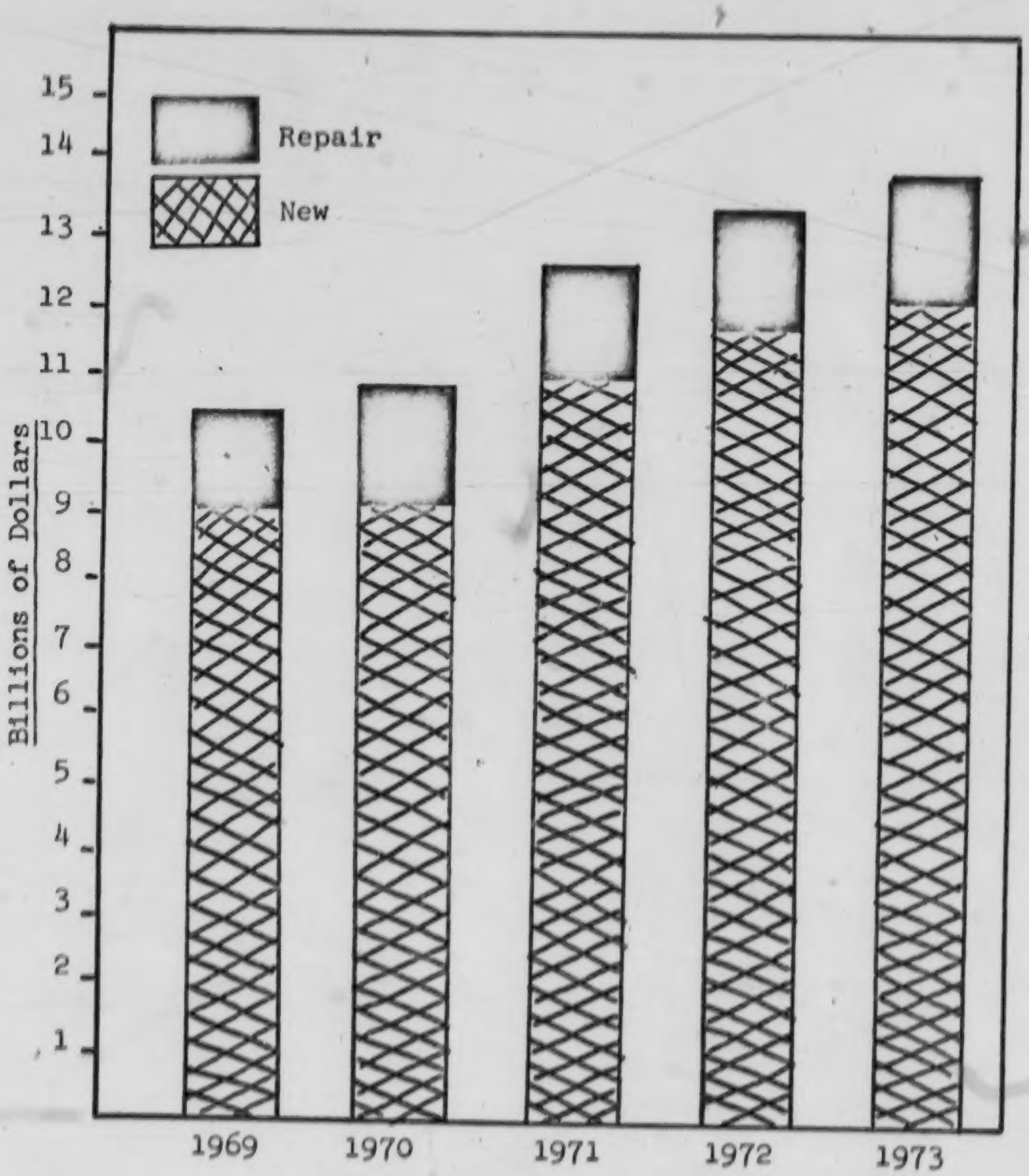


FIGURE 3

CONTRACT CONSTRUCTION IN CANADA 1969-1973



Contract construction itself for the years 1969-1973 is shown in Fugure 3 and has been running at over 12% of Gross National Expenditure.

Figure 2 sets out the total value of construction work performed in Canada during the years 1964-1973 by new and repair categories and in current and constant dollars. Current dollar volume indicates an average increase of 8.94% per year, whereas the real average increase has been only 4.25% per year.

The division of the contract construction dollar between new and repair has remained fairly constant, split approximately at 13%-87% for repair and new construction respectively. The average yearly increase in current dollars for the two has been near 8%; the real growth of course has been much lower.

Over half a million people are employed by the construction industry in Canada and their labor is valued in excess of six billion dollars. Of these totals over 400,000 are involved in contract construction, producing labor valued at over five billion dollars.[3] This labor value represents approximately 35% of the total value of contract construction, the remainder being the cost of materials used (about 40%) and overhead and profit (about 25%).[4]

---

[3] Broemser estimates that 5½% of the U.S. labor force is employed in the construction industry. He also states that the ratio of low employment to high employment ranges from 60 to 80%, depending on the type of construction. Presumably, this ratio would be even lower in Canada due to extreme seasonality. (G.M. Broemser, "Competitive Bidding in the Construction Industry," unpublished Ph.D. dissertation, Stanford University, 1968, p. 18).

Characteristics of the Industry

Concentration

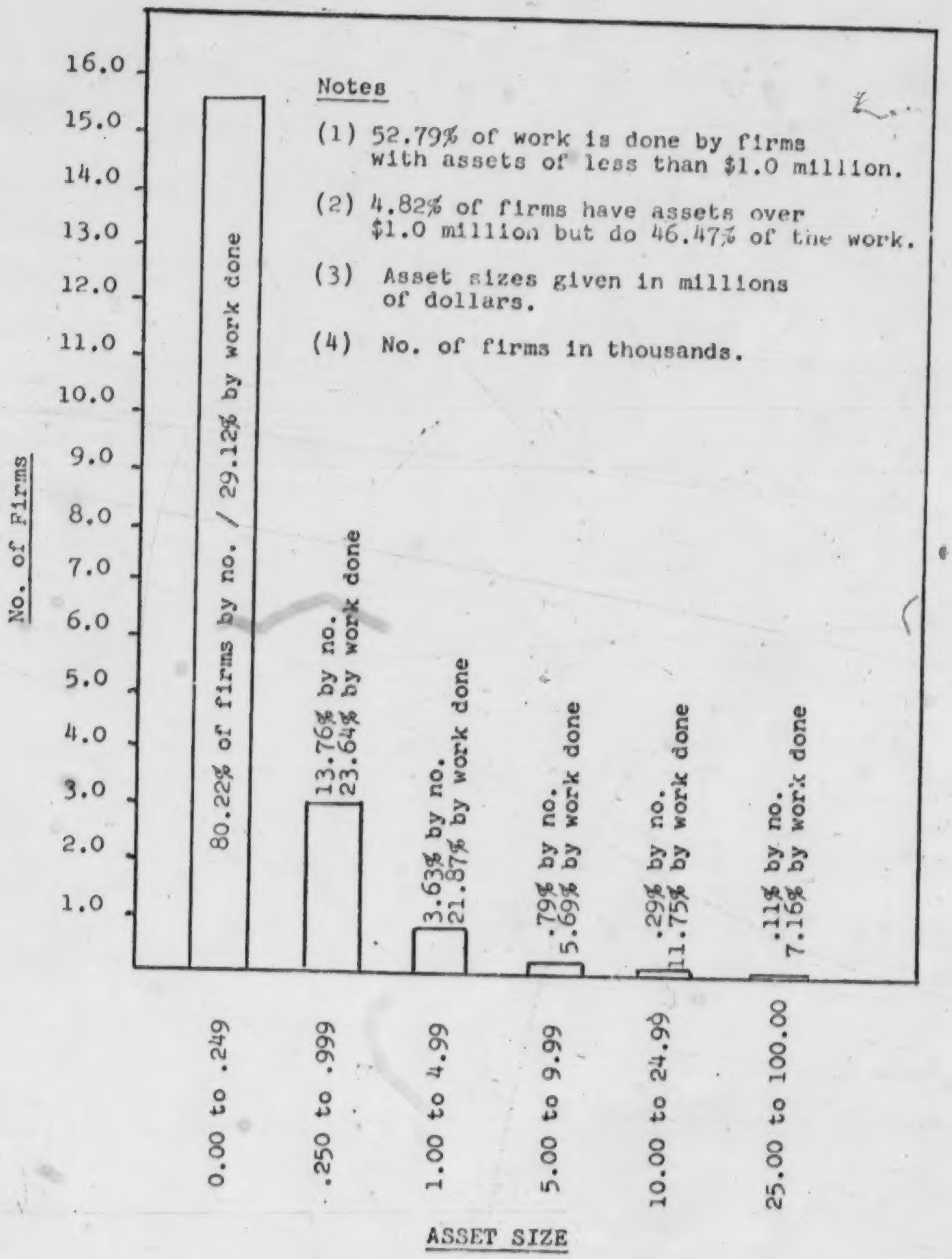
The construction industry is much more competitive than many other industries. The largest firm has only a small percentage of the total market. In 1969 the twenty-one largest firms held 7.16% of the market. Firms with total assets of less than $250,000 constitute 80.22% of the total number of firms in the industry. Figure 4 graphs the number of construction firms by asset size, giving an indication of the degree of concentration in the industry. The competition is expecially keen among the firms with assets of less than one million dollars. The limited assets of these companies means that their market will be restricted to jobs for which their assets (mostly machinery and equipment) are sufficient. The larger companies can use part of their assets to compete on the smaller jobs but the smaller companies cannot expand their assets to compete on the larger jobs.

---

[4] The U.S. figure for labor content (non-white collar or clerical) has been calculated as 30% of each revenue dollar. (Peter J. Cassimatis, "The Performance of the Construction Industry 1946-1965," unpublished Ph.D. dissertation, New York School for Social Work, 1967, p. 229.)

FIGURE 4

NO. OF FIRMS AND % WORK DONE BY ASSET SIZE - 1969



Notes

(1) 52.79% of work is done by firms with assets of less than $1.0 million.

(2) 4.82% of firms have assets over $1.0 million but do 46.47% of the work.

(3) Asset sizes given in millions of dollars.

(4) No. of firms in thousands.

Geography influences the degree of competition, in that firms with assets of under one million tend to be one-office operations in which communication and travel costs rise quickly as the distance of the job from the office increases. The competition among smaller firms becomes an intra-provincial activity and sometimes a local urban activity.

Relation to Government Policy

The construction industry is one of the very first industries to be affected by changes in governmental fiscal policy. The ease with which a government can declare projects "go" or "no go" and the volume of government expenditures on construction make the timing of government construction jobs an attractive tool for fiscal planners. Table 1 gives the actual expenditures (in millions of dollars) on construction by the various sectors of the economy. Only housing outranks government departments as a source of construction revenue. Housing accounts for nearly one third of all monies spent on construction, whereas government departments provide about one fifth of the total. Utilities, which in Canada are mostly government owned, are responsible for an additional 16 to 17% of construction activity.

Given the sensitivity of the housing sector to government monetary policy through the vehicles of N.H.A.

and C.M.H.C., and the government's influence over general availability of mortgage funds, and considering the proportion of construction activity that housing represents, it is clear that both monetary policy and fiscal policy have significant impact on the construction industry. These proportions have remained constant within a percentage point or two over the last three years (1971-72-73). The figure represents aggregates, and would be more meaningful if further broken down by type of work performed. Contractors should be classified as roadbuilders, heavy construction, building construction, etc. Utilities should be separated into power companies, transportation, sewer and water, etc., and governments should be similarly classified by type of work performed, if much meaningful interpretation is expected. These divisions are not presently available in Canada, but such a study on contractors has been done in the U.S. by Peter J. Cassimatis.[5] Comparing his data on contractors with ours, we find that the Canadian contract revenue dollar gives 5% more to labor, 5% more to overhead and profit and fully 10% less to cost of materials. A more detailed analysis of contractor's financial and operating characteristics will be presented later in the chapter.

---

[5] Cassimatis, Ibid.

TABLE 1

CONSTRUCTION ACTIVITY IN CANADA BY SECTOR 1971-1973

Actual and Percent of Total

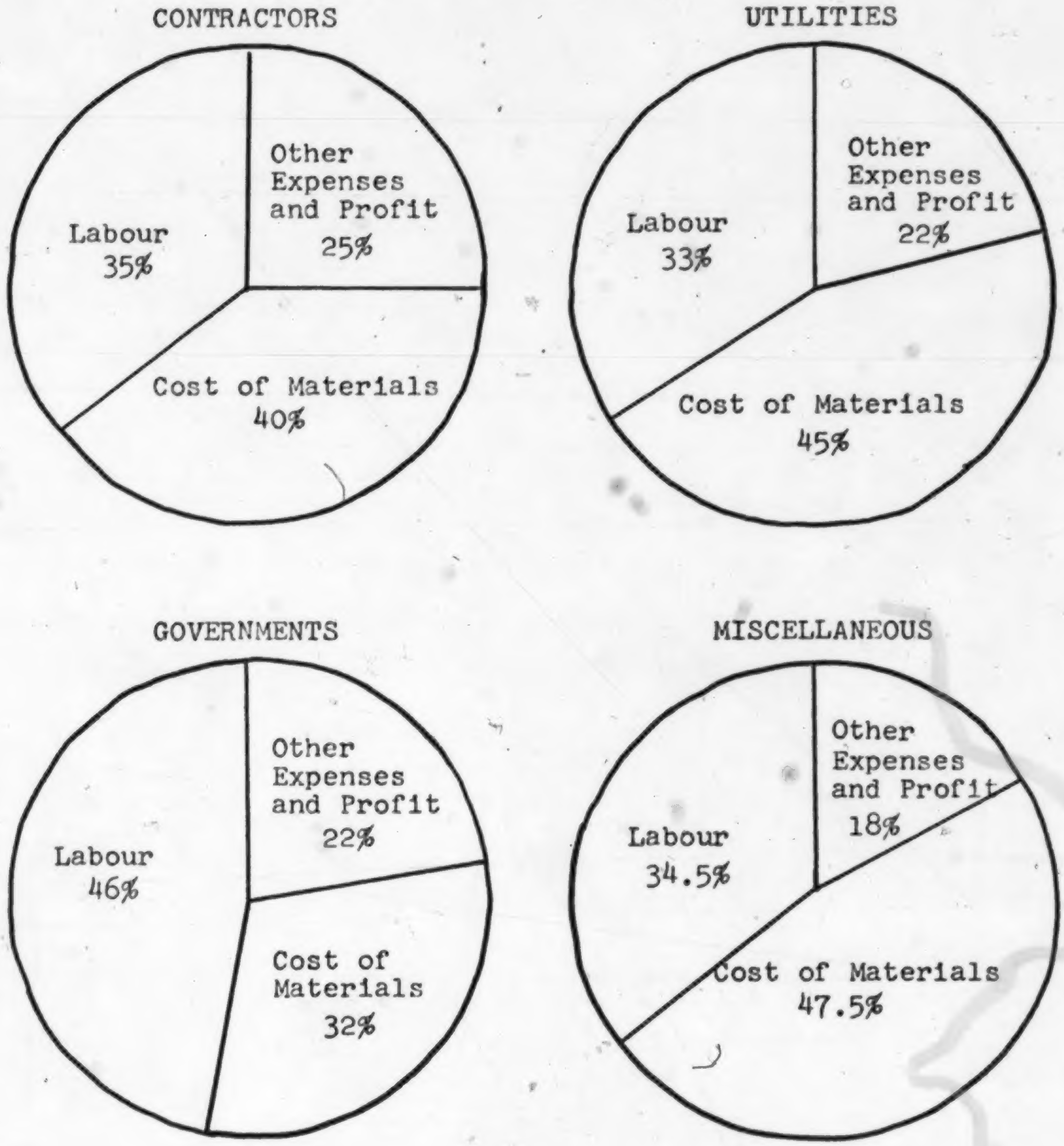
Actual = in millions of dollars

	1971		1972		1973	
	Actual	%	Actual	%	Actual	%
Agriculture & Fishing	318	2.00	360	2.11	386	2.13
Forestry	61	.38	68	.40	88	.48
Mining, Quarrying & Oil Wells	1464	9.23	1316	7.73	1326	7.34
Manufacturing	1080	6.81	1006	5.90	1122	6.21
Utilities	2620	16.52	2820	16.56	3216	17.81
Construction Industry	24	.15	22	.13	22	.12
Housing	4976	31.37	5760	33.82	5853	32.41
Trade-Wholesale & Retail	245	1.54	266	1.56	310	1.72
Finance, Insurance & Real Estate	545	3.44	783	4.60	969	5.36
Commercial Services	247	1.56	229	1.34	285	1.58
Institutional Services	1317	8.30	1147	6.74	1020	5.64
Government Departments	2965	18.69	3251	19.09	3460	19.16
TOTAL	15862	100	17028	100	18057	100

FIGURE 5

DIVISION OF THE CONTRACT REVENUE DOLLAR

The contract revenue dollar in Canada is divided roughly as follows:



Employment

Canadian data on employment in the construction industry is published in equivalent man years instead of in actual numbers employed. This practice gives a better idea of the significance of employment in the construction industry, as it compensates for the actual fluctuating levels due to the seasonal nature of construction work in Canada. The following table gives an idea of the level of employment in the various sectors involved in construction work and the value of the work they produced. From this table, it would seem that labor productivity is increasing, and the value of work performed per man year is also increasing in every sector in each year. This, however, is not the case; the value of work performed per dollar of labor input has remained substantially constant in each sector over the last three years. The cost of materials installed per dollar of labor input has also remained constant during this period.

The differences between sectors are pronounced and significant. The utilities have the highest value of work produced per dollar of labor input while also having the highest remuneration per man year of any sector.

The government involvement in construction has the poorest remuneration per man year, and also has by far the poorest value of work produced per dollar of labor input. The cost of materials installed per $1 labor input

TABLE 2

LABOR PRODUCTIVITY IN CANADIAN CONSTRUCTION BY TYPE OF CONSTRUCTOR

1971, 1972, 1973

Employer and Year		Labor Content in Equivalent Man Years	Remuneration per Man Year	Value of work Produced 100,000	Value of Work per $1 Labor	Value of Work per Man Year	Cost of Materials Installed per $1 Labor
Contractors	1971	461,979	9,800	12,702,839	2.80	27,496	1.13
	1972	438,558	10,938	13,541,061	2.82	30,876	1.141
	1973	425,132	11,811	14,172,161	2.82	33,335	1.139
Utilities	1971	52,204	10,073	1,588,786	3.02	30,434	1.37
	1972	52,052	11,234	1,749,340	2.99	33,607	1.35
	1973	56,003	12,108	2,036,192	3.00	36,358	1.36
Governments	1971	48,635	8,210	878,854	2.20	18,070	.70
	1972	49,536	9,162	986,657	2.17	19,917	.699
	1973	49,428	9,934	1,066,208	2.17	21,570	.6989
Miscellaneous	1971	26,612	8,957	694,855	2.91	26,109	1.42
	1972	26,022	9,983	750,481	2.88	28,840	1.37
	1973	25,333	10,770	783,313	2.90	31,315	1.35

Contractors perform by far the largest portion of construction work done in Canada.

also incidates that the government is significantly less productive than the three non-government sectors involved in construction.

It is noteworthy that although the remuneration per man year throughout the construction industry seems high in comparison with other industries, the construction industry is highly sensitive to weather, economic conditions and government policy (fiscal and monetary) and that few workers actually work a whole year.

Entry and Exit

Entry to the construction industry is relatively easy because of the low capital requirements and the ability to function on a small scale, (i.e. there are small jobs available). The ease of establishing a contracting business is probably one of the reasons for the high failure rate in the industry. In the first three quarters of 1970 and 1971 construction firms represented approximately 14% of the failures and 17% of the liabilities of all failed firms in Canada. In the light of the proportion of all firms represented by construction firms:

PROPORTION OF CONSTRUCTION FIRMS TO ALL FIRMS BY NUMBER

1968 17,694/192,754 = 9.17%
1969 19,203/207,424 = 9.25%

this is a disproportionately high number of failures.

Financial Characteristics of Contracting Firms

Statistical information on the construction industry in Canada and especially on financial characteristics of firms has been difficult to obtain until very recently. Statistics Canada now publishes information in its Corporation Financial Statistics series, but most of this information is four years old at time of publication. Fortunately there is little reason to suspect that financial characteristics of construction firms should have changed in the interim. The basic nature of construction activity and procedures for bidding have not changed significantly in the last four years.

This section contains an analysis of the available financial data on construction firms operating in Canada. The object of the analysis is the discovery and explanation of the significant financial characteristics peculiar to contractors.

The aggregate balance sheets and income statements are examined in detail and compared with similar information for manufacturing industry and the total of all industries. Profit and loss corporations are separated and differences noted. Income statements and balance sheets are then separated according to size of assets of the firms and reviewed again.

Table 3 presents a comparison of the aggregate balance sheets of the total of construction companies, the total of manufacturing companies and the total of all companies. Each item on the balance sheets is numbered and the explanation of what is included in each item can be found under the corresponding number in Appendix "A" Balance Sheet Definitions.

For the purposes of our analysis and to facilitate comparison these balance sheets have been converted into percentages of total assets or liabilities and equities as the case may be.

Assets

The total current assets of construction companies constitute slightly over 66% of total assets whereas in manufacturing current assets are only 45% of total assets. The total of all companies have about the same amount of their assets in current form (45%). The current assets of construction companies are concentrated in Trade Accounts Receivable and Inventories. The construction accounts receivable are nearly twice as high as in manufacturing and almost three times as high as the total of all companies. Inventories are even higher than in manufacturing and three times as high as in all companies. The inventories in construction firms, however, consist almost exclusively of work in process not progress billed. Since construction is a custom order activity inventories in the ordinary sense are very low.

Depreciable assets, consisting of buildings and equipment are less than for all companies (construction 36.89%, all companies 37.78%) and only about one half as high as in manufacturing (68.85%). Building contractors would have even less in equipment as the total construction figure includes roadbuilders who have heavy equipment requirements.

The labor intensive nature of the construction industry means that most construction companies have relatively simple balance sheets on the assets side, consisting essentially of current assets to finance the materials being installed by the labor. Approximately one third of the construction dollar goes to labor, whereas in manufacturing only about one fifth of each revenue dollar goes to labor.

Liabilities

Total current liabilities make up over 51% of total liabilities and owner's equity; non-current liabilities are 23% and owner's equity is 25.31% for the total of all construction firms. The comparable figures for all manufacturing firms indicate that manufacturers are more heavily financed by equity (49% vs. 25% for construction), similarly financed by long term debt (24% manufacturing vs. 23% construction), and that construction relies heavily on current liabilities to finance its activities (51% construction vs. 26% manufacturing). The total of all companies

TABLE 3

COMPARISON OF BALANCE SHEETS

ASSETS - 1969

	Total Construction Percentages	Total Manu-facturing Percentages	Total All Companies
01 Cash	3.66	1.69	5.43
02 Marketable Securities	3.46	2.72	7.38
03 Accounts Receivable	27.51	14.17	10.07
04 Inventories	25.39	21.52	8.69
05 Prepaid Expenses	.50	.54	.46
06 Due from Affiliates	3.07	4.17	2.17
07 Deposits and Advances	1.41	4.57	11.09
08 Mortgages (Current)	.97	.05	.42
09 Other Current Assets	.57	.43	.26
10 TOTAL CURRENT ASSETS	66.40	45.76	45.98
11 Land	2.94	1.68	2.30
12 Buildings	10.35	19.19	11.68
13 Equipment and Other	26.54	49.01	26.09
14 Total Depreciable Assets	36.89	68.85	37.78
15 Less Accumulated Depreciation	17.62	33.81	14.54
16 Depreciable Assets - Net	19.26	35.05	23.23
17 Depletable Assets - Net	.16	1.76	2.72
18 TOTAL NET FIXED ASSETS	22.36	38.49	28.25
19 Mortgages	1.59	.27	6.74
20 Loans and Notes Receivable	1.12	.64	.75
21 Long Term Investments	1.32	.93	4.47
22 Investments in Affiliates	1.56	8.02	7.64
23 Advances to Affiliates	3.59	4.48	4.99
24 Deferred Charges	.29	.66	.54
25 Other Assets	1.79	.73	.64
26 TOTAL OTHER ASSETS	11.25	15.74	25.77
27 TOTAL ASSETS	100.00	100.00	100.00

Note: Totals may not add due to rounding.

TABLE 3

COMPARISON OF BALANCE SHEETS

LIABILITIES AND EQUITY - 1969

		Total Construction Percentages	Total Manu-facturing Percentages	Total All Companies
28	Bank Loans	8.43	6.42	3.84
29	Short Term Loans	1.35	.80	23.48
30	Accounts Payable	20.66	8.95	5.60
31	Taxes Payable	1.49	1.73	.76
32	Long Term Debt Due within Year	3.09	.73	.66
33	Dividends Payable	.03	.24	.14
34	Advances and Prepayments	12.30	.89	.74
35	Due to Affiliates	2.33	4.94	2.97
36	Other Current Liabilities	1.92	1.53	1.02
37	TOTAL CURRENT LIABILITIES	51.61	26.25	39.22
38	Deferred Income	.57	.18	.55
39	Due Shareholders or Affiliates	7.47	7.79	6.92
40	Mortgage Debt	11.39	.88	3.38
41	Bonds and Debentures	1.32	8.32	7.31
42	Other Long Term Debt	3.78	3.73	6.68
43	Less Due within One Year	3.09	.73	.66
44	Net Long Term Debt	13.39	12.19	16.66
45	Reserve for Future Income Tax	1.46	3.88	1.51
46	Other Liabilities	.18	.30	.19
47	TOTAL NON-CURRENT LIABILITIES	23.09	24.36	25.79
48	TOTAL LIABILITIES	76.35	50.61	65.01
49	Common Shares	2.30	12.75	9.35
50	Preferred Shares	2.52	3.75	4.49
51	Retained Earnings	19.65	29.34	15.87
52	Subsidiary Profits in Surplus	0	.26	.25
53	Surplus Reserves	.25	.54	1.23
54	Other Surplus	.59	2.75	3.78
55	TOTAL EQUITY	25.31	49.39	34.99
56	TOTAL LIABILITIES AND EQUITY	100.00	100.00	100.00

is similarly financed by long term debt (25%) and midway between construction and manufacturing on equity finance (35%) and short term liabilities (40%).

The current liabilities that contractors use to finance their work consist mainly of trade accounts payable and advances and prepayments. Advances and prepayments represent payments received for work to be done or items to be supplied within the year. Trade accounts payable are nearly three times the level in manufacturing and four times as high as in the total of all companies. This reflects the relative ease of obtaining credit from suppliers and is one of the reasons for the ease of entry into the industry.

In the longer term debt category, mortgage debt (line 40) is an area where construction data differs significantly from manufacturing and total all companies. The figure for construction (11.39%) is over four times the total of all companies and compares to almost no mortgage debt in the manufacturing sector. Bonds and debentures play a small part in financing construction firms (1.32%), whereas manufacturers use bonds and debentures for 8.32% and the comparable figure for the total of all companies is 7.31%. One explanation for this difference is that contractors seldom have publicly traded shares and generally do not have access to the open money market.

Percentage Balance Sheets by Asset Size

Construction firms vary in size from one man operations to companies with over 100 million dollars in assets. There will therefore be many market segments (both geographic and product) between these extremes. The percentage balance sheets for Canadian construction companies by size of assets are presented in Table 4 and reviewed to determine the major differences in financial characteristics between different sized firms.

Total current assets as a percentage of total assets are constant at 69% for firms with assets of under five million but this figure drops 8-9% to 61-62% for firms with assets of over five million. Most of this differential is attributable to smaller percentage cash and accounts receivable balances. Trends are clearly discernible in the three major components of current assets as the size of firms increases. Firstly the percentage of assets constituted by cash declines steadily as asset size increases. For firms with under one quarter million assets cash is 8.4% of assets, over twice as high as for firms with over one quarter million assets and eight times as high as for firms with over twenty-five million assets. Secondly, accounts receivable decrease steadily as size of assets increases, with firms with under one quarter million assets having 31.8% in receivables and firms with over twenty-five million having 38% of assets as inventory.

Fixed assets are a relatively constant proportion of total

TABLE 4

CONSTRUCTION PERCENTAGE BALANCE SHEETS BY ASSET SIZE
1969 ASSETS

ASSETS	Under 250,000	250,000-999,999	1,000,000-4,999,999	5,000,000-9,999,999	10,000,000-24,999,999	25,000,000-99,999,999
Number of Companies	15,405	2,958	698	65	56	21
01 Cash	8.40	3.71	2.88	2.28	1.49	1.05
02 Marketable Securities	3.87	3.72	4.31	5.81	3.47	1.29
03 Accounts Receivable	31.80	31.32	30.18	28.41	20.67	17.34
04 Inventories	18.16	23.69	24.70	18.35	29.25	38.29
05 Prepaid Expenses	.77	.46	.58	.45	.34	.21
06 Due from Affiliates	2.61	2.14	3.69	3.15	5.23	1.90
07 Deposits and Advances	1.62	1.62	1.42	1.57	1.69	.47
08 Mortgages (Current)	1.26	1.95	.75	.72	.23	.20
09 Other Current Assets	.29	.39	.83	.70	.64	.69
10 TOTAL CURRENT ASSETS	68.83	68.04	69.37	61.44	63.04	61.46
11 Land	2.44	3.22	2.72	4.41	3.73	1.90
12 Buildings	6.99	10.27	10.18	15.85	12.38	10.48
13 Equipment and Other	34.90	25.68	29.26	25.54	18.73	17.46
14 Total Depreciable Assets	41.90	37.60	39.44	41.39	31.10	27.95
15 Less Acc.Depreciation	22.50	19.51	19.71	18.35	13.44	8.02
16 Depreciable Assets-Net	19.39	18.08	19.71	23.06	17.65	19.93
17 Depletable Assets-Net	.09	0	.20	.25	.37	.10
18 TOTAL NET FIXED ASSETS	21.93	21.34	22.65	27.68	21.76	21.94
19 Mortgages	1.42	3.15	.99	1.01	.83	1.36
20 Loans & Notes Receivable	.74	1.25	1.25	.25	1.66	1.07
21 Long Term Investments	.83	1.56	1.28	1.42	2.15	.70
22 Investments in Affiliates	.10	.27	1.42	3.09	3.97	2.59
23 Advances to Affiliates	.84	2.61	2.13	4.48	5.30	9.21
24 Deferred Charges	.59	.01	.20	0	.09	.47
25 Other Assets	4.66	1.56	.68	.47	1.16	1.13
26 TOTAL OTHER ASSETS	9.23	8.82	7.97	10.86	15.19	16.59
27 TOTAL ASSETS	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 4

CONSTRUCTION PERCENTAGE BALANCE SHEETS BY ASSET SIZE
1969 LIABILITIES & EQUITY

LIABILITIES	Under 250,000	250,000-999,999	1,000,000-4,999,999	5,000,000-9,999,999	10,000,000-24,999,999	25,000,000-99,999,999
28 Bank Loans	7.96	9.72	8.26	5.79	6.64	10.50
29 Short Term Loans	3.30	1.50	1.28	.45	.11	.17
30 Accounts Payable	22.73	22.13	24.30	22.30	15.93	13.37
31 Taxes Payable	1.67	1.29	1.62	2.12	1.46	.89
32 Long Term Debt Due	3.25	4.00	3.45	1.65	2.72	1.91
33 Dividends Payable	0	0	0	0	0	.18
34 Advances and Prepayments	2.50	7.90	11.79	12.64	20.80	25.58
35 Due to Affiliates	.62	3.06	2.58	3.47	3.32	1.52
36 Other Current Liabilities	2.91	2.67	1.43	2.00	1.02	.88
37 TOTAL CURRENT LIABILITIES	45.07	52.30	54.78	50.16	52.04	55.04
38 Deferred Income	.11	1.10	.92	1.06	0	.13
39 Due Shareholders or Aff.	11.92	7.31	5.17	7.75	4.46	8.04
40 Mortgage Debt	5.94	13.77	12.64	14.61	10.61	11.04
41 Bonds and Debentures	0	0	.52	2.02	1.47	5.49
42 Other Long Term Debt	4.89	4.25	4.09	2.00	2.54	3.10
43 Less Due within One Year	3.25	4.00	3.45	1.65	2.72	1.91
44 Net Long Term Debt	10.76	14.05	13.81	17.00	13.71	17.75
45 Reserve for Future Inc.Tx.	.15	.72	1.92	2.50	2.64	2.04
46 Other Liabilities	.11	0	.21	.29	0	.62
47 TOTAL NON-CURRENT LIAB.	19.89	23.19	22.05	28.61	20.87	28.58
48 TOTAL LIABILITIES	64.94	75.50	76.84	78.78	72.92	78.36
EQUITY						
49 Common Shares	3.46	1.23	1.63	2.36	1.79	3.97
50 Preferred Shares	3.56	1.45	2.49	.65	3.43	2.83
51 Retained Earnings	27.75	21.54	18.12	17.18	19.59	8.69
52 Subs.Profits in Surplus	0	0	0	0	0	0
53 Surplus Reserves	0	0	.17	0	1.25	.08
54 Other Surplus	.25	.26	.69	.81	1.00	.87
55 TOTAL EQUITY	35.05	24.49	23.15	21.21	27.06	16.37
56 TOTAL LIAB.&EQUITY	100.00	100.00	100.00	100.00	100.00	100.00

assets regardless of firm size (22%). The "Other Assets" category increases (percentage-wise) as the size of firms does. This is due mainly to the larger proportion of assets devoted to investments in and advances to affiliates by larger firms.

The liability side of the balance sheets shows a number of distinct trends in proportions as the size of firms varies. Most noteworthy is the steady decline in equity as firm size increases. Firms with assets of under one quarter million were financed 35% by equity, whereas the largest firms were financed only 16% by equity. This trend is even more pronounced when the level of shareholders and affiliates loans is scrutinized, for this too decreases as asset size increases. The large decrease in equity and shareholder loan financing for large firms is compensated for by increased current liabilities. The outstanding element responsible for the increasing current debt is advances and prepayments. Firms with assets under one quarter million were financed only 2½% by advances and prepayments while the ability to get advances and prepayments increases steadily with size, the largest firms having over 25% of their financing from this source. Accounts payable decrease steadily as asset size increases, probably because advances and prepayments have been used to keep them very current.

The smaller firms have larger proportional accounts receivable and larger proportional accounts payable than bigger firms but the differential between these proportions is also larger for small firms than for big firms. It can be concluded that small firms have a larger proportion of their equity financing their receivables than larger firms.

TABLE 5

DIFFERENCE IN PROPORTION OF ACCOUNTS RECEIVABLE AND ACCOUNTS PAYABLE

	Under 250,000	250,000-999,999	1,000,000-4,999,999	5,000,000-9,999,999	10,000,000-24,999,999	25,000,000-99,999,999
Acc. Rec.	31.80	31.32	30.18	28.41	20.67	17.34
Acc. Payable	22.73	22.13	24.30	22.30	15.93	13.37
Net Proportion of Assets Financing Rec.	9.07	9.19	5.88	6.11	4.74	3.97

It would seem that larger firms both collect and pay their bills faster than small firms. Their ability to do so is probably a function in part of better management and in part of the nature of the contracts. The very large contracts, done by very large firms, are often negotiated, at least concerning progress payments and advances and prepayments. The small contractor is generally expected to fully finance his work until it is completed.

The next step in examining contractors' financial characteristics is to analyze the nature of the operating statements. A comparison of aggregate operating statements for total construction, total manufacturing and total all companies segregated into profit and loss corporations and translated into percentage terms for comparison purposes is presented. To complete the financial analysis a comparison of operating statements of construction companies separated by asset size and given in percentage terms is presented and analyzed.

Table 6 shows in percentage terms a comparison of operating statements for total construction, total manufacturing and the total of all companies segregated by profit and loss corporations. Examining the make-up of the revenues of profit corporations, it points out that sales and service revenues constitute approximately 97% of total revenues for both construction and manufacturing, but less (approximately 90%) for the total of all companies. The difference in revenue make-up between companies not engaged in construction or manufacturing and those that are consists of proportionately larger interest and dividend income. The division of the revenue dollar by source within each category (construction, manufacturing and all companies) does not vary significantly between profit and loss corporations.

The total expenses in profit corporation is significantly higher in construction companies than in manufacturing firms or in the total of all firms. This is reflected in the net profit before tazes and non-recurring items (line 25). Construction profits are 3.39% lower than in the total for all firms and 2.62% lower than in manufacturing. The data used to compile Table 6 does not give a breakdown of salaries paid to owners, but it is very likely that the difference in profit levels can be accounted for by the drawing of disproportionately high salaries by owner-managers in the construction industry. Such a breakdown is available for the United States and that is the case there.

The only major source of differences in expenses between the construction, manufacturing and overall data occurs in the materials and salaries and wages categories. If we consider Gross Profit as the difference between total revenues and the cost of materials and salaries and wages (line 11 - line 12 and line 13), the figures for Gross Profit are: construction 18.93%, manufacturing 24.54% and all companies 29.50%.

The higher Gross Profits for manufacturing and all companies is somewhat eroded through higher interest and other expenses. The most significant deviation in cost proportions is the salaries and wages item. Construction companies expend over 8% more in salaries and wages than do manufacturers and fully 12% more than the average of all companies. Most of this reflects the labor intensive nature of the construction industry but some of it likely reflects the drawing of profits by owner-managers as salaries. Until figures are available

TABLE 6

TOTAL CONSTRUCTION, TOTAL MANUFACTURING AND TOTAL ALL COMPANIES INCOME STATEMENT BY PROFIT AND LOSS CORPORATIONS

1 9 6 9

		PROFIT CORPORATIONS			LOSS CORPORATIONS		
		Total Con-struction	Total Manu-facturing	Total All Companies	Total Con-struction	Total Manu-facturing	Total All Companies
	INCOME						
01	Sales - Products	94.00	96.16	82.67	94.37	96.95	79.33
02	Sales - Services	3.11	1.71	7.57	3.13	1.82	12.18
03	Rental Income - Real Est,	1.03	.17	1.11	.77	.17	2.13
04	Rental Income - Other	.65	.47	.92	.49	.18	1.57
05	Commissions	0	.04	1.06	0	.06	.86
06	Bond Interest	0	.07	.64	0	0	.15
07	Mortgage Interest	.01	.01	.80	0	0	.44
08	Other Interest	.03	1.69	3.01	.36	.16	.74
09	Dividends	.01	.62	1.23	0	.11	.20
10	Other Income	.64	.50	.95	.76	.49	2.36
11	TOTAL INCOME	100.00	100.00	100.00	100.00	100.00	100.00
	EXPENSES						
12	Materials	52.29	55.31	52.85	55.49	60.07	55.98
13	Salaries and Wages	28.78	20.15	17.65	31.85	24.84	20.99
14	Repairs and Maintenance	1.59	1.14	1.30	2.14	1.25	1.96
15	Rent	.32	.54	.90	.61	.81	1.26
16	Royalties	0	.42	.27	0	.22	.10
17	Bond Interest	.05	.33	.80	.05	.85	.87
18	Mortgage Interest	.48	.04	.26	.47	.13	.82
19	Other Interest	.65	.81	2.87	1.38	1.72	2.70
20	Taxes Other than Direct Taxes	.37	.49	.72	.43	.54	1.09
21	Depreciation	2.41	2.93	2.71	2.97	3.44	3.68
22	Depletion and Amortization	0	.14	.23	0	0	.59
23	Other Expenses	7.67	9.75	10.53	9.63	11.34	15.52
24	TOTAL EXPENSES	94.67	92.05	91.28	105.05	105.33	105.63

TABLE o con't.

TOTAL CONSTRUCTION, TOTAL MANUFACTURING AND TOTAL ALL COMPANIES INCOME STATEMENT BY PROFIT AND LOSS CORPORATIONS

1969

		PROFIT CORPORATIONS			LOSS CORPORATIONS		
		Total Con-struction	Total Manu-facturing	Total All Companies	Total Con-struction	Total Manu-facturing	Total All Companies
25	Net Profit Before Taxes and Non-Recurring Items	5.32	7.94	8.71	-5.05	-5.33	-5.62
26	Non-Recurring Items	.35	.42	1.18	.19	.31	- .64
27	Net Profit Before Taxes (Direct)	5.67	8.37	9.89	-4.85	-5.62	-6.26
28	Provision for Income Taxes	1.91	3.32	3.03	- .65	- .74	- .43
29	Mining and Logging Taxes	0	.04	.06	0	0	0
30	Net Profit (Loss) After Taxes	3.77	5.00	6.79	-4.21	-4.88	-5.83
31	Cash Dividends Declared	-.61	-1.71	-2.46	- .29	- .66	- .56
32	Stock Dividends Declared	-.02	- .08	- .11	- .01	0	- .08
	COST OF SALE - PRODUCTS						
33	Sales - Products						
34	Less Cost of Sales						
35	Gross Profit						

on the extent of such practices, it is impossible to draw relevant conclusions as to the relative profitability of construction versus other sectors.

Other differences worth noting in profit corporations are the level of income tax and level of dividends. Income taxes for construction companies represent only 1.91% of the revenue dollar whereas the comparable figures for manufacturing and all companies are respectively 3.32% and 3.03%. The probable explanation for this is the small business deduction under Canadian tax law. Since under pre-1972 tax legislation the first profit dollars earned by a company were subject to lower tax rate than subsequent earnings in each year, the lower percentage reserved for tax payment by construction companies probably reflects the large number of small firms in the industry. The lack of significant dividend payments in the construction sector (.61% versus 1.71% for manufacturing and 2.46% for the average of all companies), is also a function of the smallness of construction firms. Very few construction firms have assets and earnings records that would meet the requirements for listing on a stock exchange. The lack of public distribution of shares and with it the general lack of separation of ownership and management allows construction owners to draw their money in terms of salaries leaving only what is necessary for re-investment in the business. It is interesting to note that the difference in net profit after taxes and dividends is not nearly as great as before taxes and dividends (construction 3.15%, manufacturing 3.21% and total all companies 4.22%).

An examination of the make-up of expenses in loss corporation reveals that no single factor stands out as responsible for the unprofitability. The proportion of expenses seems quite stable, although, of course, higher within each category. What the money-losing corporations in all sectors seem to have in common is bad management of expense levels as opposed to proportions.

Table 7 presents a comparison of income statements for the construction sector by asset size. Unfortunately, no distinction between profit and loss corporations was available by asset size.

The proportion of revenues by source do not vary significantly as size changes with the exception of an increase in real estate and rental incomes among the very large firms. Sales of products and services, in the case of construction, usually mean contracts and upgrading of prior contracts, and account for about 97% of total revenues.

The expenses and gross profits are fairly stable as size of firm changes. The proportion of expense constituted by cost of materials seems to increase as size increases, but this is almost exactly offset by decreases in the proportion of expense attributable to salaries and wages. The reason for this is not clear. Outside of these observations, there are no clearly discernible trends in expenses, profits or dividends

TABLE 7

COMPARISON OF INCOME STATEMENTS (PERCENTAGES) TOTAL CONSTRUCTION BY ASSET SIZE

1969

		Under 250,000	250,000-999,999	1,000,000-4,999,999	5,000,000-9,999,999	10,000,000-24,999,999	25,000,000 99,999,999
	Number	15,405	2,958	698	65	56	21
01	Sales - Products	92.82	95.12	94.41	94.24	95.26	92.22
02	Sales - Services	5.62	2.82	2.56	1.80	.44	1.06
03	Rental Income - Real Estate	.46	.86	.89	1.46	1.19	2.74
04	Rental Income - Other	.31	.41	.77	.73	.84	1.35
05	Commissions	0	0	0	0	0	0
06	Bond Interest	.09	0	0	0	0	0
07	Mortgage Interest	.19	.14	.07	0	0	0
08	Other Interest	.19	.19	.31	.75	.52	.44
09	Dividends	0	0	0	0	.44	.29
10	Other Income	.42	.46	.66	.68	1.27	1.62
11	TOTAL INCOME	100.00	100.00	100.00	100.00	100.00	100.00
12	Materials	48.97	54.67	53.17	55.48	60.24	48.15
13	Salaries and Wages	32.62	29.00	29.11	24.30	24.86	29.69
14	Repairs and Maintenance	1.27	2.31	2.44	1.87	.72	.58
15	Rent	.60	.35	.28	.21	.15	.34
16	Royalties	0	0	0	0	0	0
17	Bond Interest	0	0	0	0	0	.44
18	Mortgage Interest	.28	.42	.60	.71	.59	.80
19	Other Interest	.71	.80	.67	.57	.72	1.67
20	Taxes Other than Direct Taxes	.42	.36	.43	.36	.23	.36
21	Depreciation	2.47	2.42	2.51	3.24	2.09	3.21
22	Depletion and Amortization	0	0	0	0	0	0
23	Other Expenses	9.21	7.20	7.67	9.06	5.53	10.75
24	TOTAL EXPENSES	96.59	97.56	96.93	96.03	95.17	96.02

TABLE 7 con't.

COMPARISON OF INCOME STATEMENTS (PERCENTAGES) TOTAL CONSTRUCTION BY ASSET SIZE
1969

		Under 250,000	250,000-999,999	1,000,000-4,999,999	5,000,000-9,999,999	10,000,000-24,999,999	25,000,000 99,999,999
25	Net Profit Before Taxes and Non-Recurring Items	3.44	2.46	3.07	3.99	4.83	3.90
26	Non-Recurring Items	.18	.29	.30	1.54	.19	.31
27	Net Profit Before Direct Taxes	3.62	2.74	3.38	5.51	5.04	4.21
28	Provision for Income Taxes	.90	.93	1.63	2.38	2.29	2.37
29	Mining and Logging Taxes	0	0	0	0	0	0
30	Net Profit (Loss) After Taxes	2.72	1.81	1.74	3.11	2.77	1.84
31	Cash Dividends Declared	-.67	-.29	-.38	-.60	-.97	-.73
32	Stock Dividends Declared	0	0	0	0	0	0

as size of assets changes. The "other expense" category probably buries such expenses as bonding expense, reports and licensing expense, travel, board and lodging, freight expense, and other controllable expenses which might vary by size of firm.

It is impossible to over-estimate the importance of careful analysis of the individual contractor and his own particular financial characteristics.

The analysis here of contractors as a group can serve only as a rough guide. Each particular market segment of the industry will have different characteristics, for example, road builders will have different equipment and hence depreciation expenses than building contractors.

A rough idea of the absolute size of contracting firms' sales and profits according to assets employed can be gained from reading Table 8.

TABLE 8

1969 AVERAGE SALES AND INCOME BY ASSET SIZE

Asset Size (Millions)	Average Sales $	Average Net Income Before Taxes and Extraordinary Items	Average Net Income After Taxes
.0 - .25	154,865.00	$ 5,322.00	$ 4,206.00
.25 - 1.0	674,577.00	16,565.00	12,204.00
1.0 - 5.0	2,564,899.00	78,939.00	44,699.00
5.0 - 10.0	7,166,153.00	286,153.00	223,076.00
10.0 - 25.0	17,173,214.00	830,357.00	471,428.00
25.0 - 100.0	27,885,714.00	1,090,476.00	514,285.00

The turnover of sales/assets cannot be exactly seen from this table because within each range of asset values there are likely to be many more firms in the bottom of the range than in the top.

Now that we have examined some of the characteristics of contractors, we will turn in the next section to the consideration of the characteristics of contracts and the procedures and processes involved therein.

The Nature of Contracts

Broemser aptly described the type of contract we are dealing with: "A construction prime contract, a unique indivisible object is awarded to the lowest bidder at the fixed price he bid, on the basis of closed competitive bidding done only once."[6] Statistics Canada defines construction as "The creation, renovation, repair and demolition of immobile structures and the alteration of the natural topography of the ground" (see Appendix). We are concerned with the processes and the procedures of award as described by Broemser to do construction as defined by Statistics Canada.

Once a contractor has been awarded a contract he must set to work to perform the construction in accordance with the architectural or engineering plans and specifications, making sure that he also complies with the terms and conditions set out in the contract documents. The price a contractor receives for the work is the only compensation he receives for doing the work as contracted and as specified. Throughout the rest of this paper the cost to the contractor to do a contract is assumed to be calculated by an "engineering estimate." This "engineering estimate" must also be assumed to include an estimate of costs incurred in meeting the requirements of contract documents as well as engineering specifications. Naive contractors often forget to include such "hidden costs" and then express surprise that their estimates do not prove accurate.

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[6] Broemser, Ibid, p. 55

Costs resulting from meeting contract document requirements are usually the bid bond, the labor and materials payment bond, the performance bond, various insurance requirements, and costs of reporting to the owner or his representative on the progress of work. The bonding requirement has special significance in the study of contract bidding. As mentioned above there are three types of bonds. These bonds are required by the owners in order to protect themselves from the default or bankruptcy of the contractor.

The procedure works as follows: the owner of the work to be done requires that the contractor submit at the time of his tender a bid bond of some specified amount or certain percentage of the tender price. The contractor must then arrange with a surety to provide such a bond. The purpose of this bond is to protect the owner in the event that the lowest bidder should decide not to proceed with the work (perhaps because his price is too low or because he becomes insolvent in the interim). If this happens, the surety pays the amount of the bond to the owner and seeks its redress from the contractor. It has been argued that bid bond requirements have often been overly stringent. Since the owner always may award the contract to the second lowest bidder if the first one defaults, the bid bond should be only sufficient to compensate the owner for the higher price he must pay the second lowest bidder plus his inconvenience in so doing. Marvin Gates has done some work in this area with considerably more success than his work in bid price determination.[7]

The labor and materials payment bond and the performance bond (usually 50% of contract price each) are required by the owner when the contract documents are signed; at this time the bid bond is returned to the successful contractor. The purpose of these two bonds is to assure the owner that, if the contractor defaults after construction has begun, sufficient funds will be available to complete the job satisfactorily.

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[7] The practice of requiring excessively high bid bonds has been severely criticized in the industry. M. Gates has shown that security requirements accompanying tenders should not exceed 3.24 $C^{0.734}$ where C is the cost of the job. (Marvin Gates, "Statistical and Economic Analysis of a Bidding Trend," *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers*, Paper 2651, Vol. 86, No. CO3, November 1960, p. 13). The writer would like to point out, however, that a simpler approach than Gates' would be to assume that for comparable jobs the spreads between low and second low bidder are normally distributed. By simply calculating the mean and standard deviation of the historical distribution of "spreads on comparable jobs, one may set any confidence level and then easily calculate the size of the bid bond required as the value which will give the desired confidence level times the standard deviation of the historical distribution of spreads on comparable jobs.

In return for providing these bonds the sureties demand from the contractor information on the financial status of the company and its principals, a fee, and usually contingent claims on assets.

Virtually all contracts of a significant size have bonding requirements in Canada. Because of this, bonding can provide key information about a contractor. The sureties, after perusing a contractor's financial records, will set a bonding limit for the contractor which acts in effect as a capacity constraint. As each bond is applied for, the contractor's work on hand but undone is subtacted from his bonding limit and if the bond requested is less than that it is granted. The size and number of jobs a contractor bids during any given time can be limited by this bonding requirement.[8]

The contractor receives the job at the fixed price he bid for it and there are no provisions for excalation due to increased costs. Although the job may extend over a period of months or even years, the contractor must anticipate his costs and provide a complete working installation by a specified date. Strikes, shortages, vascillating costs and delivery times, bankruptcies of sub-contractors, organization and co-ordination of sub-trades and his own forces are all the responsibility of the prime contractor and all for a fixed price, paid only after the work has been done.

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[8] The suggested procedure for evaluating a construction company and setting its bonding limit is described in Luther E. Mackall, Surety Underwriting Manual, 2nd ed., Rough Notes Company, Indianapolis, Indiana, 1963, pp.105-106.

The contractor receives payments on the basis of percentage of work completed, usually monthly. Since the administrative processing of these claims can be very slow--ranging from two to eight weeks--the contractor must be prepared to finance 45-90 days of construction activity internally. Part of this may be financed on terms by suppliers but the bulk of it must be financed through the contractor's own cash or equivalent. Earlier in the chapter we noted the heavy current position of construction companies as compared to other businesses. When individual companies need more short term cash they will often indulge in the practice of unbalanced bidding.

Unbalanced bidding is done on contracts where progress payments are made on the basis of unit prices submitted with a bid but the contract itself is let on a lump sum basis. A contractor in need of cash may submit very high unit prices for work to be done early in the life of the contract, correspondingly decreasing the prices of units of work done late in the contract. In this way he succeeds in shifting large cash payments into the first progress payments. Unbalanced bidding is very prevalent and has many pitfalls as well as advantages. A few studies have been done in this area.[9]

Sub-contracting is an integral part of construction contracting. The prime or general contractor cannot afford to keep as members of his permanent staff the necessary specialists and tradesmen to do all jobs he may get. In order to secure steady employment for themselves these tradesmen tend to form small specialty contracting firms to market their services. This also enables them to acquire and keep busy the equipment necessary in their particular trade. The prime contractor will accept sub-contract prices from reliable trade contractors and suppliers, use the lowest of these as a basis for his cost estimate, and add a certain amount to cover organization and coordination expenses. If the amount of the sub-contract is large or if the sub-contractor considered not too reliable, the general contractor may require a bond from the sub-contractor but this is not generally the case. There may be many tiers of contractors on a particular job (e.g., sub-contractors, sub-sub-contractors, etc.). This specialization provides predictable employment for the tradespeople, better planning in each area, and enables the prime contractor to extract completion dates, progress schedules and fixed prices from the sub-contractors, thus making his job of predicting the cost of the job slightly easier.

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[9] Unit pricing creates the problem of "unbalanced bidding" which is a while area of study itself. Unbalanced bidding is where a bidder computes his unit costs and then submits unit bid prices greatly in excess of and greatly below his units costs with the total coming out to the same amount as if he had used "standard" or "normal" mark-ups on all unit costs. The motivation for this procedure is two-fold. Firstly, a contractor may over-price parts of a job that will be performed earliest thus giving him badly needed working capital, or it may be that he feels the architect or consulting engineer has made a mistake in estimating the bid quantities (in which case he will over-price the particular unit) or a lesser quantity (in which case he will under-price the given unit and over-price others he is more sure of.

Armed with some knowledge of what a construction contract is and is like we shall proceed to examine how it is secured.

Description of the Bidding Process

An individual or organization who is planning on constructing something will usually go to an architectural or engineering firm, explain what they have in mind and have these professionals design it for them. Once the item has been designed and financing has been secured, the owner will usually commission the same design firm to have the item built and to supervise its construction. At this stage the engineering firm will either negotiate a price with a selected contractor, invite selected tenders for the work, or open the work to public tender. (Some owners such as some governments and large corporations have their own design and supervision departments.)

If selected tenders are wanted the engineering firm or department will invite certain contractors that they know are qualified to bid or they may invite all contractors to "prequalify." The bulk of contract work, however, is opened to public tender and qualifications must be established before starting work if the bidder is successful and if so requested.

Public tenders are advertised in the daily newspapers, trade magazines and trade newspapers. In addition to this there are several "building report" services who specialize in reporting on upcoming tenders and reporting the results of tenders which have closed. For an annual subscription fee these services mail daily reports on current tenders to subscribers.

The newspaper advertisements list a brief description of the work offered for tender, where plans specifications and tender documents can be obtained, the date and time of tender closing, the amount of deposit on plans, etc., and the details of bid security deposits or bid bonds. The building report services also list who has taken out plans and tender documents when this information is available from the owner or his agent.

If a contractor's interest is aroused in a particular job, he will secure the plans and specifications and tender documents for a more serious look. If he still feels he wants to bid the job, he will do a preliminary cost estimate and advise his surety of his intention to bid the job. He will then begin a serious engineering estimate and detailed "take-off" on the job. If he wishes to use sub-trades, he will advertise the fact and the time by which he wants sub-trade prices to be in his hands. Usually it is not necessary to advertise for sub-trades as they will ferret out all the general contractors and offer a price. The engineering estimate usually involves an expensive field site examination and testing of soils and other conditions. For this reason, and because his bonding capacity limits his selection of jobs, a contractor must select which jobs to bid very carefully. If he bids a particular job and gets it, he may wipe out an opportunity to bid on a potentially more lucrative job in the near future. The question of which jobs to bid has been largely ignored academically although a couple of elementary articles have been published by Paranka.[10] Leaving the choice of which available jobs to bid, let us consider the contractor's procedure once a job has been selected and an engineering cost estimate prepared.

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[10] Research into the decision of which jobs to bid or when to make cost estimates has been practically non-existent. Stephen Paranka has offered a procedure in a recent article. This procedure is really nothing more than comparing alternatives on the summation of a linear combination of weights and factors. (Stephen Paranka, "Competitive Bidding Strategy--A Procedure for Pre-Bid Analysis," Business Horizons, 14, June 1971, pp. 39-43.) The same concept was suggested by B.V. Dean in 1965 in regard to determining probability of award of National Defense Research Contracts in the U.S.A. (Burton V. Dean, "Contract Award and Bid Strategies," I.R.E. Transactions on Engineering Management, Vol. 12, No. 2, June 1965, pp. 53-59.

When his "direct costs" or "job costs" have been estimated the contractor will apply some estimate of "overhead" or "office overhead" to the cost and use this as his total cost. Next he will decide on the amount of profit he is willing to "gamble" for and add this to his cost to arrive at his lump sum bid price. The surety will then be notified of the final bid bond amount and preparation of the tender document begins. If unit prices are required, the contractor will divide his lump sum price among the units as he sees fit and enter these prices in the tender form. All necessary signatures and seals are applied, job schedules, completion dates, contingent or alternate prices are noted, receipt of addendums (changes) are acknowledged, all calculations in costing and final prices are double or triple checked, the executed bid bond is enclosed and last-minute changes in costs are adjusted for via one open "plug figure" and finally the tender is sealed and delivered to the owner or his agents.

Bidding Procedures

During the final hours of the tender preparation there is much confusion and busy work. The sub-trades are being revised, new prices are being received, and the checking and double-checking is in progress. It is in the midst of this hectic time that most bidding managers are making their final decision on mark-up levels and the degree of unbalanced bidding to be used. There is a multitude of factors to be considered--the accuracy of costs, the competitive environment, the short and long range goals of the company, immediate cash or employment needs and a hundred others. The consideration of these factors is all too often hurried and/or merely intuitive. We shall refer to this area as Strategy and discuss it at length in the next chapter.

CHAPTER III

THE STRATEGY OF BIDDING

In the contract construction industry a job which has been put up for tender is almost always awarded to the lowest qualified bidder. By requiring that each bidder bond himself for the full price of the job, the owners eliminate the consideration of non-price factors in their awarding. If there was a tie, non-price factors could come into play, but competitive bids in this industry virtually never result in a tie. The lack of homogeneity of product from one bid to another, the high labor content, and the multitude of parts that go into a job make it extremely unlikely that any two competitors would have the same cost and mark-up structures for a particular job.

The condition of winning a bid can be expressed as:

Let B_{ij} = Bid of Competitor i on Job j

$$\text{Then: } B_{1j} \text{ wins} = B \quad \text{MIN} \quad \overset{N}{\underset{i=2}{B_{ij}}}$$

i.e., competitor number one wins if and only if his bid is lower than that of his lowest competitor. An analyzing competitor will want to "win" a certain number of jobs but not necessarily any jobs. If his lowest competitor submits a bid at or below cost, the analyzing competitor may not want to "win" that job. The selection of which jobs to bid is of just as much importance as determining the price to be bid. These are the two major bidding decisions to be made, i.e., which jobs should be bid[11] and what price should be submitted on the jobs actually bid. The two decisions are related in that the historical success rate on jobs of a particular type can logically influence the decisions of which jobs to bid, yet the historical success rate itself is dependent on the bid prices submitted on each job. Many of the same factors therefore influence both decisions.

The bidding decisions, as all decisions, will hinge on the objectives of the decision maker. Which jobs and what price to bid will depend on what the bidder hopes to accomplish. No two bidders are likely to have the same set of objectives at the same time and individual bidder's objectives will change over time. There are hundreds of possible objectives a bidding manager may hold and each may affect bid price determination and job selection to varying degrees and in different directions. Some of the more common and significant ones are examined here.

(1) To maintain work for key employees

Often when a contractor is running low on work he will sacrifice profit by lowering his mark-up on a bid in order to improve his chances of being awarded the contract. Although he may even lose some money on the job he will be able to keep in his employ key workers who will more than earn back the loss when there is more work being let.

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[11] The problem of selection of which jobs to bid is briefly discussed by Stephen Paranka's 1971 article, op. cit.

(2) To vary market share

A contractor may feel that he is operating below or not far enough above his break-even point and decide to expand his share of the market by taking less mark-up and increasing his volume. On the other hand he may feel he is at the point where he has over-extended himself and is straining the corporate resources, both financial and managerial. He may then hope to improve the company's profitability by being more selective on the jobs he bids, choosing only those directly within his sphere of competence and/or by raising the mark-up levels on the jobs he bids.

(3) To minimize competitors' profits

Since contractors who take out plans on upcoming jobs are listed publicly, the other contractors usually know who is bidding a particular job. If a new competitor is trying to break into the market, the other competitors may be willing to sacrifice some profit to prevent him from getting the opportunity to gain expertise in one particular field.

(4) To maintain critical cash flows

Each contractor usually has several jobs under construction at the same time, each job requiring varying amounts of capital for different lengths of time. Critical cash flows can sometimes be maintained by securing a contract that will have suppliers who will carry the costs for sixty to ninety days, freezing the first one or two progress payments on that job for use in financing other jobs already underway but perhaps suffering from slow payment difficulties. If a bidder is in such a predicament, he may sacrifice profit in order to secure the cash flow.

(5) To maintain reputation and likelihood of future invitations to bid

Occasionally a contractor receives invitations to bid on a "closed" job, i.e., bids are by invitation only. Often when this happens the contractor is busy or not particularly interested in the contract because of more attractive opportunities available. In such a case the contractor will usually submit a very high bid, knowing that he will have little chance of "winning." This is done as a public relations gesture in order to maintain the likelihood of future invitations which may be more lucrative.

(6) To maximize total expected profit

If a contractor's objective is to maximize his total expected profit, different interpretations are possible when different time horizons are considered. If short run total expected profits are to be maximized, then plant and management fixed costs are of little relevance. However, if longer run total expected profits are to be maximized, plant and management capacities can be varied and their costs must be considered. The time horizon problem is particularly relevant in the construction industry where there are many small firms and the appropriate time horizon may well be closely tied to the personal objectives and utility functions of the proprietor or manager.

(7) To meet some target level of return on invested capital

Some bidders will never bid below an amount that will yield their target rate of return. This is usually only possible where the cost of bidding is not high as with "pencil contractors." (Pencil contractors are contractors that entirely sub-let the job and require full bonding of the sub-contractors.) In general, contractors (especially the small ones) are not very financially sophisticated. They may attempt to get some level of return on investment but tend to translate this into a constant percentage mark-up on their bids and do not pay enough attention to the time differences on jobs with similar dollar profits.

(8) To gain expertise and/or technical knowledge in a new market area (geographic or product)

If a contractor wishes to gain expertise in a new product or geographic area, he may be willing to sacrifice some short run profits in expectation of more profit over the long run. The lack of expertise in a particular market segment will mean that the contractor may have to bid at or only slightly above his cost in order to get the job. Once he has secured a job or two at cost his expertise will increase and his costs will drop, providing him with some profit and placing him on a competitive basis with other contractors who previously had that portion of the market to themselves.

The objectives listed above are a few of many that contribute to the bidder's final decision of which job he will bid and how much he will mark it up. With such a range of possible objectives it is clear that rational analysis of competitive bidding requires firstly a thorough and detailed knowledge of the firm. Its characteristics, financial and managerial, must be known. Knowledge of the firm that sets out to analyze the bidding in its industry is only the starting point, knowledge of the job to be bid and of the competing contractors is essential also. This competitive environment is very complex and before analysis proceeds some of its important dimensions are discussed.

JOB VARIABLES

Number of Bidders

The number of bidders or the expected number of bidders may or may not have a significant influence on the bidding behaviour of competitors. The point is argued in the literature with one writer basing his whole method on the assumption that the number of competitors is a significant variable and another writer claiming that the number of competitors is irrelevant.

Size of Job

The size of the job is very probably an important factor influencing the mark-up policy of competitors. Presumably mark-up would be high on small jobs and decrease as jobs got larger. Marvin Gates has published the results of his analysis of the influence of the size of job on bidding behaviour and his results tend to corroborate the assumption. Gates, however, neglects to analyze the size of job in relation to the capacity of the competitor.

Knowledge of the Bidder

Knowledge of special conditions such as prime sources of supply, likely technical problems, or subtle risks may influence the mark-up policy of a competitor. Special knowledge may also increase a competitor's estimating accuracy making his mark-up policy more relevant and his bid more sensible in the light of his objectives.

The Cost of Bidding

It is usually the contractor's responsibility to establish for himself the nature of ground conditions, the availability of utilities, quality of access and other general site conditions prior to submitting a bid. Knowledge of these conditions is essential to an intelligent bid because the cost of the job is usually very sensitive to them. The cost of obtaining the necessary knowledge of conditions and of costing and planning the job prior to bidding it is significant, especially in choosing which of the jobs available for tender ought to be bid.

The Frequency of Bids

The frequency of bids may affect the competitor's attitude toward the job in that he may anticipate equal or better opportunities in the near future (assuming bids are let often) and may prefer to stay with a fairly high mark-up on the present job. Alternatively, if bids are seldom let, a competitor may be very anxious to get some profit now by reducing his mark-up and getting the job as opposed to distant future profits.

Time from Submission of Bid to Award of Contract

If a contractor knows that an owner may have a long time between calling tenders and awarding the job, he may increase his mark-up in order to compensate for having his bonding capacity tied up for that anticipated long time.

Length of Time to do Job as Related to Anticipated Job Profit

This is a very important factor that has been entirely overlooked in the literature. If a contractor is bidding a job of a certain dollar value, he will or should adjust his mark-up in accordance with the anticipated duration of the job.

Portion of Job Sub-Contracted

When a general contractor accepts sub-contracts for portions of the work, he relieves himself of much of the organization and planning effort for that portion of the job. The mark-up on the sub-contracted portion, therefore, should not be as high as on the portion done entirely by a contractor's own forces, i.e., the portion of the job to be sub-contracted is a significent variable with respect to mark-up policy. This has only recently been acknowledged in the literature.

The Capabilities and Expertise of the Bidder

Some competitors have the ability to perform certain jobs more economically or in a shorter time period than others due to better methods, equipment or planning. Where the nature of a job is such that it is clear such competitive advantage or disadvantage will come into play, the mark-up policies of competitors may be affected. The contractor to whom the advantage accrues must decide how much, if any, of that advantage he wishes to translate into increased mark-up.

In addition to factors which pertain to the job itself there are factors related to the nature of the firm and the industry which influence bidding strategy. These factors are often vital and cannot be ignored in an intelligent approach to competitive bidding. Some of them are listed and discussed in the following section.

NON-JOB AND NON-OBJECTIVE FACTORS

(1) Reputation of the Owner

When a contractor is deciding whether or not to bid a particular job one of the first considerations is the reliability of the owner. Does the owner have the financial resources to pay for the job when the time comes? Will the payments be on time? The contractor must satisfy himself that the owner is reliable in these areas or at least mark up the job sufficiently to compensate for what risk of non-payment or late payment he may perceive.

(2) Reputation of Designers and/or Consulting Engineers

The field supervision and interpretation of contract documents and job specifications can mean the difference between profit and loss on a contract. Usually the consulting engineers are given wide powers of discretion in the contract documents. A well established working relationship with the supervising engineering firm is essential. Good lines of communication enable a contractor to resolve the problems that inevitably arise on a job quickly and amiably. Extra work orders for afterthoughts of the owner or oversights by the architects can be lucrative if the consulting engineers are competent and friendly. On the other hand an incompetent supervising engineering staff results in disputes over who made which mistake and how it should be remedied. An unfriendly or hostile engineer may result in costly delays of job and costly drawn-out negotiations over extra work. The reputation and disposition of consulting engineering firms may therefore influence the mark-up on a job.

(3) Industry Capacity

Governments and other public organizations call most of the jobs let by competitive bid. The provincial, municipal and federal governments are seldom aware of what each other is doing as far as construction planning and coordinating are concerned. This often results in uneven workloads for the construction industry. Government departments that realize they may be left with a surplus in their budget at the end of their fiscal year strive to spend it before it is taken off their next year's budget. Political motivations often delay or accelerate construction. Fiscal policy changes hit government construction early because it is easy to identify. These factors, compounded by the short Canadian construction season, result in over or under capacity for the construction industry. Depending on the prospects for tender calls contractors will vary their mark-ups. If a contractor knows that most of his competition is "booked up" with work, he will raise his mark-up on an upcoming job because he knows the competition will have to pay more for their resources since they are operating at their margin and because they are not "hungry" for work and therefore should be anticipating a higher than normal profit.

(4) Firm Capacity

As was explained in Chapter II, each contractor is required to bond himself to the owner or owner's agents for the full price of the job. Since each contractor has a finite bonding limit, individual contractors may approach their capacity even though the industry does not. If a discerning bidder can establish that certain firms are approaching or have reached their "bonding limit" or physical capacity, he may be able to rule them out as serious competition on an upcoming job and adjust his mark-up accordingly.

(5) Management Attitude Toward Risk

The bidding decision may hinge on the riskiness of a job in that different managers will have different attitudes toward the same level of risk. Competition may be better appraised or possibly ruled out on certain "risky" jobs by studying the management's attitude toward risks.

(6) Owner's Estimates

It is standard practice that the architects or consulting engineers supply to the owner an estimate of how much it will cost to perform the job. The accuracy of these estimates, and whether or not they are made available to the contractors prior to bid closing, can affect the mark-up on the job. Contractors often make use of the consulting engineers' estimates as a rough guide or check on the accuracy of their own estimating. If the consulting firm has a good record in predicting the costs to the owners, the contractors will rely to some extent on those estimates. If in the contractors' opinions the estimates are high, there may be a tendency to raise mark-ups slightly because the owner is expecting to pay a certain amount for the job and has probably budgeted for it. If the reverse situation obtains, i.e., if the consultants' estimates are considered low by the contractors, there may be a tendency to lower mark-ups slightly in order that the job is not cancelled because the owner did not budget for it. There will of course be a limit to the downward variation of mark-up.

(7) Unbalanced Bidding

Unbalanced bidding is where a bidder computes his unit costs and then submits some unit bid prices greatly in excess of his unit costs, adjusting the total contract price to a "normal" mark-up by correspondingly reducing a lump sum price. The motivation for this procedure is twofold. Firstly, a contractor may over-price parts of a job that will be performed earliest, thus giving him badly needed working capital, or it may be that he feels the architect or consulting engineer has made a mistake in estimating the bid quantities (in which case he will over-price the particular unit) or a lesser quantity in which case he will under-price the given unit and over-price others he is more sure of. Unbalanced bidding is important to bidding strategy because it is a way of disguising the true "expected" profit margin on the job.[12]

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[12] Two significant research studies have been done in this area: (1) R.M. Stark, "Unbalanced bidding models," University of Delaware--Technical Report, Department of Civil

PSYCHOLOGICAL FACTORS

The psychological analysis of competitors may reveal quirks or tendencies of which advantage may be taken during bidding. The difficulty in quantifying these factors has meant that they have usually been ignored in bidding analysis. It is impossible to know the many subtle influences that create an individual's mood on a particular day, yet the bidding manager's disposition (whether optimistic or pessimistic) may influence the outcome of the competition. The possibility of discovering quirks or tendencies, however, is much more real. Certain bidding managers may tend to mark up different types of jobs in a consistent and predictable manner. The distance from head office, the riskiness of the job, the amount of danger involved and other factors may evoke quite different yet somewhat predictable reactions from each competitor.

The field of bidding strategies is still so young that no research has been done on the influence of psychological factors on mark-up and very little empirical work exists on the influence of any factors.

There are literally hundreds of factors which influence the bidding decisions. Those discussed in this chapter are a few of the more readily identifiable ones. The bidding

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Engineering, 1966. (2) R.M. Stark and R.H. Mayer, Jr., "Multi-contract and Unbalanced Bidding Models," Bulletin of the Operations Research Society of America, No. 16-B261, 1968.

environment, especially in the construction industry, is very complex. The high levels of entry and exit, the lack of homogeneity of the product, the sensitivity of costs to innovation, and the myriad factors influencing mark-ups have discouraged any rigorous analysis of bidding processes and strategies in the industry. There are texts that deal extensively with the cost extimation of jobs, but the mark-up decision is usually dismissed in a phrase or two.

In 1956 Lawrence Friedman of the Case Institute of Technology produced the first non-intuitive analysis of bidding strategies.[13] Since then a number of articles and research papers have been published. The next chapter examines the important contributions and limitations of these works.

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[13] Lawrence Friedman, "A Competitive Bidding Strategy," Operations Research Quarterly, 4, 1956, pp. 104-112.

CHAPTER IV

REVIEW OF THE LITERATURE

In this chapter the works on competitive bidding which are relevant to the construction industry bidding process are examined. Lawrence Friedman's initial article is the basis for much of what has been written since and is therefore considered first.[14] Next, the approach taken by Gates is explained and discussed.[15]

Friedman

Friedman recognizes that a company may have more than one objective but for the purpose of his analysis assumes that the competitor's sole objective is to maximize total expected profit. He translates "total expected profit" to mean the probability of winning a contract with a particular bid price times the difference between the bid price and the cost estimate adjusted for bias. He then advocates determining win probability as the probability of winning over the first competitor times the probability of winning over the second competitor . . . . . . times the probability of winning over the nth competitor. If the number of competitors and their identity is not known Friedman uses the concept of an "average competitor" being a composite of information about individual competitors. The probability of winning against n "average" competitors is the probability of winning against one average competitor raised to nth power. The number of bidders, according to Friedman, could be estimated by linear regression analysis of cost estimates and number of bidders on past bids. He assumes the distribution of number of competitors to be poission and proceeds to graph the expected profit at each bid price and chooses the bid price which maximizes expected profit.

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[14] Friedman, Ibid.

[15] Gates, "Statistical and Economic Analysis of a Bidding Trend," pp. 13-25.

Where the number and identity of competitors are known there is no need for the "average competitor concept." Probability of winning over any competitor at a given price is computed as the area to the right of the bid price under a curve of (bid price/cost estimate) ratios which has been developed for that competitor over all jobs on which he and the analyzing competitor have bid.

Friedman's notion of relating the historical behaviour of competitors to the relatively consistent internal cost estimates set the groundwork for subsequent research and raised the issue of just how to determine win probability.

Marvin Gates set out a method for bidding analysis in a paper published in 1960.[16] It was a simple analysis of spreads over a large number of jobs. He correlated the low dollar bids with the average percent spread and then calculated the distribution of the spread. Gates advocates preparing the bid in the usual manner then analyzing the decrease in the chance of winning as various amounts are added to the bid. Unfortunately, for this method to be of any use the contractor must first know his chances of winning with his original bid. If he can estimate these by some method, he can use the same method to estimate the probability of winning with any bid. Broemser aptly described this method as "not very useful."

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[16] Gates, op.cit. pp. 13-25.

Gates, however, produced a subsequent work (March 1967)[17] which set out a formula for determining win probability, but no justification for his formula was provided until March of 1972 when Mathew Rosenshine published a paper[18] explaining that Gates' formula was a macro description of bidding observations and explaining that Friedman's model does not require the assumption of independence of competitor's bids. Although Gates' formula is correct as a description of bidding observations, it is still not useful as a precriptive aid to bid price determination.

Friedman's model appears again in the sixties advocated in an article[19] and book[20] by Park. Park uses the Friedman model, making the assumption that competitor bids are independent, while not recognizing that he has made the assumption. This is understandable in that Friedman himself did not acknowledge the assumption. Yet it results in the probability of winning being heavily dependent on "n" the number of competitors. Broemser, in his dissertation,[21] points out that Park's data comes nowhere near to fitting his predictions and that there appears to be little or no correlation between the number of bidders and the low bid amount.

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[17] Marvin Gates, "Bidding Contingencies and Probabilities," *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers*, Paper 5159, Vol. 93, March 1967, pp.75-10

[18] Mathew Rosenshine, "Bidding Models: Resolution of a Controversy," *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers*, Vol. 98, No. CO1, March 1972, pp. 143-148.

Broemser also concluded that there was no such correlation shown in his own data. He interpreted this lack of correlation to mean that the assumption of independence between competitors' bids is not valid. Broemser seemed to believe the assumption of independence to be a necessary part of the Friedman approach and since he felt the assumption was invalid he set out his own method for bid analysis. The Broemser model is a very significant one and is in fact closely related to the Friedman model. The next chapter will discuss important aspects of win probability determination in both the Friedman and Broemser models.

The problems of the single shot, sequential, and multiple bidding models are discussed in the chapter on bidding models in general. Broemser has done some valuable work in this area but

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[19] William R. Park, "How to Bid to get Both Job and Profit," Engineering News Record, 41, February 14, 1963.

[20] William R. Park, The Strategy of Contracting for Profit (Prentice Hall, Englewood Cliffs, N.J., 1966).

[21] Broemser, Ibid.

discussion of it will be reserved for that later chapter.

There have been other works published that relate to the competitive bidding situation but few that relate to competitive bidding in the construction industry. The operations research literature contains a number of game theoretic approaches to the competitive bidding problems. Although not basically inappropriate, game theory has not developed to the point where it is practical for the analysis of the complex construction bidding market. The importance of time considerations to construction bidding strategy would multiply the information required to describe the situation as a game to such proportions that the determination of these quantities would become a practical impossibility.

Most of the remaining published works are slightly modified Friedman-like approaches.

R.L. Shaffer presented an explanation of the Friedman model to The American Association of Cost Engineers 9th national meeting[22] and included an analysis of how the use of the model would have affected ten contractors if they had used it on selected jobs for which he had the bid price information. He concludes that the models are useful but his assumption of all competitors' costs being 85% of their bid price on all jobs leaves the validity of his conclusion somewhat in doubt.

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[22] R.L. Shaffer, "Competitive Strategy Models for the Construction Industry," International Journal of Computer Mathematics, 1, 1965, pp. 251-272.

J. J. Piggott in an article in the Canadian Chartered Accountant (November 1966)[23] explains how some intangible factors enter into bid pricing but little else of importance is asserted.

An often overlooked approach to the study of competitive bidding is the simulation of bidding situations via competitive bidding games. The work in this area is tremendously interesting. It was begun in July 1961 by Messrs. Howard Farrow Ltd. of England. They engaged P. C. Webb and C. E. Wheeler "to prepare a management exercise suited to the economic aspects of the operations of a typical building and civil engineering firm."[24] This first effort was really only a "see what happens" attempt rather than a carefully controlled experiment designed to show the effect of varying certain parameters of the simulated "environment." The major contribution of this experiment was that it showed that such a "bidding game" is a promising vehicle for research. The designers of the project knew nothing of "bidding models" at the time of the design. Their sole purpose was to observe human patterns in the bidding situations in a compressed time period. Unwittingly they have provided possibly the best way of testing the results of mathematical bidding models under controlled conditions. The potential of this type of research is unlimited. In 1969 a "bidding-work loading game" was devised on a functional basis, i.e., eliminating most of the relationships with the environment not directly related to bidding and work loading.[25] This game was pedigogical in nature rather than research oriented. It was much simpler in scope than the English experiment referred to above and its main significance is as a teaching aid.

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[23] J.J. Piggott, "The Construction Industry--Preparation of a Tender," The Canadian Chartered Accountant, November 1966, p. 349.

[24] P.C. Webb and C.E. Wheeler, "Operation Taurus: A Business Game Designed for the Building Industry," Journal of Industrial Economics, Oxford, Vol. 10, 1961-63, pp. 118-133.

Richard F. Barton of Texas Technological University has designed the first significant bidding research game since the original experiment in England in 1961. "Structurally, the game was a three person, non-constant sum, mixed motive, complete information, experimental bidding game with infinite alternatives on infinite pay-off Matrix, and a high level of communication among the subjects."[26] It was felt that such a game essentially described an oligopoly. Through many runs it was hoped to determine whether or not price cooperation would take place. It did not.

Statistical and analytical approaches to the bidding problem are difficult to distinguish at times. Some game theorists have recently incorporated Bayesian statistics into their work, blurring the distinction between game theoretic and statistical approaches.[27] What are usually referred to as the Statistical approaches include the elementary Friedman model and its subsequent modifications by Park,[28], Edelman,[29], Casey,[30], Gates,[31] and others. More recent and more sophisticated Statistical models coupled with empirical evidence of their application have been presented by Broemser,[32], and Drake.[33] The analytical approach begun by Clough[34] and Gates[35] with simple analysis of spreads between low bidders and second low bidders has been taken over lately by new writers with a sort of hybrid statistical-analytical approach. Among these are the models of Morin and Clough[36] and Shaffer and Micheau.[37]

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[25] Paul C. Jorgensen, Richard M. Wyshide and Leonard S. Yarborough, "Bidding-Work Loading Game," Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, October 1968, pp. 127-137.

[26] Richard F. Barton, Oligopoly Bidding Behaviour in a Quasi-Complex Experimental Game (Texas Technological University, Tubboch, Texas, 1969), p. 1.

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[27] See I.H.Lavalee, "A Bayesian Approach to an Individual Player's Choice of Bid in Competitive Sealed Auctions," Management Science, Vol. 13, A584-597, 1967, or John C.Harsanyi, "Games with Incomplete Information Played by 'Bayesian' Players": Part 1 - Management Science, Vol. 14, No. 3, p. 159; Part 2 - Management Science, Vol. 14, No. 5, p. 320; Part 3 - Management Science, Vol. 14, No. 7, p. 486.

[28] Park, Ibid.

[29] Franz Edelman, "The Art and Science of Competitive Bidding," Harvard Business Review, 43, July-August 1965, pp.53-66.

[30] B.J.Casey and L.R.Shaffers, "An Evaluation of Some Competitive Bid Strategy Models for Contractors," Construction Research Series Report No. 4, Department of Civil Engineering, University of Illinois, Urband, Ill., June 1964.

[31] Gates, "Bidding Contingencies and Probabilities," pp.75-107.

[32] Broemser, Ibid.

[33] W.D.Drake, "The Design and Implementation of a Competitive Bidding Strategy," unpublished Ph.D. dissertation, University of Michigan, 1964.

[34] Richard H. Clough, Construction Contracting (John Wiley and Sons, New York, 1960), p. 92.

[35] Gates, "Statistical and Economic Analysis of a Bidding Trend, pp. 13-25.

In June 1965 two works were published on contract award and bidding strategies for research and development contracts.

Burton V. Dean advocated the use of a linear combination of weights and factors to evaluable whether a contract proposal should be accepted.[38] The customer or owner would then prepare a proposal evaluation matrix as follows:

	Customer Factors and Weights	
Customer Proposal Pi	Factors F_1 F_2 . . . F_n Weights W_1 W_2 . . . W_n	Proposal Value from Customer Point of View Vi
P_1	A_{11} A_{12} . . . A_{1n}	V_1
P_2	A_{21} A_{22} . . . A_{2n}	V_2
P_m	Am_1 Am_2 . . . Am_n	Vm

$$Vi = A_{ij} W_j \qquad = 1, 2, \ldots m$$

A procedure for determining probability of award including the relative frequency of obtaining the MAX V_1, V_2, Vm is outlined, after which the analysis proceeds as in Friedman's approach. Here again the implicit assumption of independence between competitors' bids is made with the result that win probabilities are inordinately dependent on the number of competitors.

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[36] T.L.Morin and R.H.Clough, "Opbid-Competitive Bidding Strategy Model," Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Paper 6690, Vol. 96, June 1970, pp. 88-97.

[37] R.L.Shaffer and Terry W. Micheau, "Bidding with Competitive Strategy Models," Journal of the Construction Division, Proceedings of the American Society of Civil Engineers, Paper 8008, Vol. 97, No. CO1, March 1971, pp. 113-126.

[38] Dean, Ibid.

A similar approach is explained in a concurrent and co-authored publication in Management Science.[39]

The utility of a linear combination of weights and factors such as Dean suggested is limited in the construction bidding situation where the customer or owner decides the award on price alone.

In 1971 Stephen Paranka of Colorado State University published an article showing that a linear combination of weights and factors could be of use in the pre-bid analysis or job selection stage of competitive bidding situations where the final award is a function of price alone.[40] Paranka suggests that factors such as plant capacity, expected competition intensity, delivery or scheduling, quantity or job size, following opportunities and profits should be assigned factor levels for each upcoming bid opportunity and multiplied by standard weights that remain constant for the company over time. The bid opportunities would then be ranked in order, of their values as determined by the sum of the products of individual weights and factors.

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[39] Burton V. Dean and R.H. Culnan, "Contract Research Proposal Preparation Strategies," Management Science, Vol. 11, No. 8, June 1965, pp. 187-189.

[40] Paranka, op. cit.

The concept of pre-bid analysis and ranking of bid opportunities is commendable but more study is required on which factors should be considered and how they should be weighted.

Franz Edelman developed a model of the competitive bidding situation which took into account managerial judgements as to certain intangible factors affecting probability of award.[41] His model was developed for an industry with relatively homogeneous product, and where non-price factors do enter into consideration in award, nevertheless, construction bidding analysts can draw two useful tools from Edelman's model. The first tool, which could certainly be used to advantage, is the quantification of managerial judgements about intangible factors affecting award probabilities and probable bid prices. The second tool of analysis relevant to the construction bidding situation is the expansion of the objective function in models to include a regret criterion or cost of not getting the job. The details of Edelman's approach are not relevant to our situation but the concepts of a wider objective function and consideration of intangibles are crucial to the development of better bidding analysis.

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[41] Edelman, op. cit.

Rubey and Milner,[42] Ackoff and Sasieni,[43] and Churchman, Ackoff and Arnoff[44] have written operations research texts which include sections on competitive bidding, but they have done no more than to paraphrase Marvin Gates and Friedman.

All models postulated in the literature have as an integral part of them as estimation of the probability of winning a contract. The next chapter examines the two worthwhile approaches taken by Friedman and Broemser and shows how they are related. Two methods likely to improve accuracy are then suggested. Finally, the objectives of the determination of win probability are described via an elementary rank order approach.

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[42] H. Rubey and Walker W. Milner, "A Statistical Approach for Bidding," Ch. 15 in Construction and Professional Management (The MacMillan Co., New York, 1966).

[43] Russel L. Ackoff and M. Sasieni, "Competitive Problems," Ch. 13 in Fundamentals of Operations Research (Wiley, New York, 1968).

[44] C.W.Churchman, R.L.Ackoff and E.L.Arnoff, "Bidding Models," Ch. 19 in Introduction to Operations Research (Wiley, New York, 1957).

CHAPTER V

WIN PROBABILITY DETERMINATION IN CLOSED COMPETITIVE BIDDING SITUATIONS

The literature on closed competitive bidding to date contains two distinct approaches to the problem of win probability determination.

The first to appear and the more widely known is the approach advocated by Lawrence Friedman in 1956.[45] Friedman advocates studying previous bidding data and comparing it to internal cost data.

Let: (1) B_{ij} denote the bid price of competitor i on job j.

(2) C_{ij} denote the cost price of competitor i on job j.

Under Friedman's approach the analyzing competitor would develop frequency distributions of the ratios of competitor's bids to his costs for jobs which they both had bid.

Assume the analyzing competitor to be competitor 1 i.e., i=1

Competitor 1 would proceed to develop distributions as follows:

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[45] G.M. Broemser, op. cit.

(1) $\frac{B_{2j}}{C_{1j}}$ over all j on which they both bid.

(2) $\frac{B_{3j}}{C_{1j}}$ over all j on which they both bid.

(3) etc.

(4) $\frac{B_{nj}}{C_{1j}}$ over all j on which they both bid.

Assume the following distributions are arrived at for 3 competitors.

If competitor 1 decides to bid $\frac{B_{1j}}{C_{1j}}$ on some upcoming bid j, then the probability that he will win (Friedman says) is given by the product of the areas to the right of $\frac{B_{1j}}{C_{1j}}$ and under the other competitors' curves.

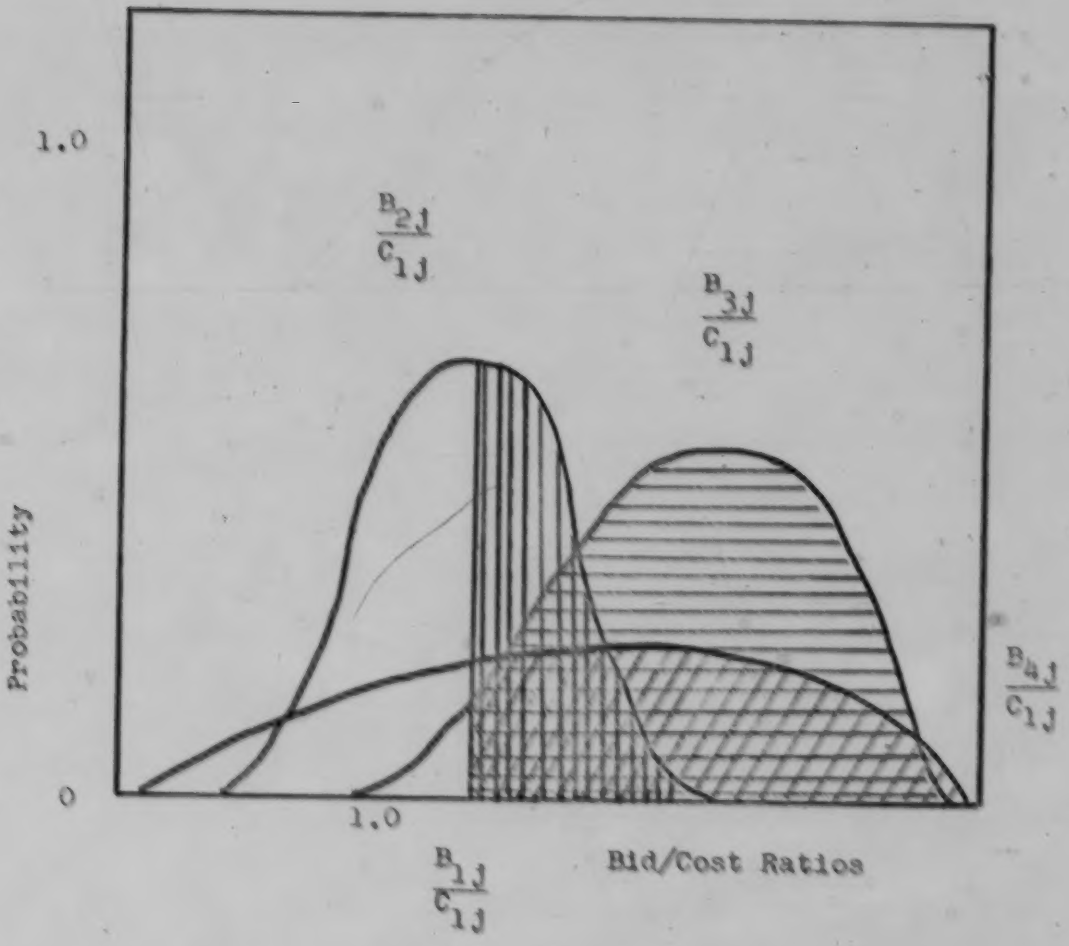
Dropping the reference to the job, this could be characterized as:

$$P\ (\text{Winning}) = \left[\int_{\frac{B_1}{C_1}}^{\infty} f\left(\frac{B_2}{C_1}\right) d\,\frac{B_2}{C_1}\right]\left[\int_{\frac{B_1}{C_1}}^{\infty} f\left(\frac{B_3}{C_1}\right) d\,\frac{B_3}{C_1}\right]\left[\int_{\frac{B_1}{C_1}}^{\infty} f\left(\frac{B_4}{C_1}\right) d\,\frac{B_4}{C_1}\right]$$

Friedman goes on to include the concept of an "average bidder" to allow for the situation where particular competitors are not known but where their number is known or can be estimated.

FIGURE 6

HISTORICAL BID/COST PROBABILITY DISTRIBUTIONS



His "average bidder" curve is nothing more than the summation of the distributions of individual competitors. The probability of being lower than k average bidders is simply:

$$P\ (\text{Winning} / k \text{ Average Bidders}) = \left[\int_{\frac{B_1}{C_1}}^{\infty} f\left(\frac{B_A}{C_1}\right) d\frac{B_A}{C_1} \right]^k$$

This approach contains a number of assumptions which may be disputed, namely that competitors' bids are independent and that the cost of the analyzing competitor is an adequate estimate of competitors' costs. The second approach was studied by G. N. Broemser in his Ph.D. thesis[46] and is discussed below.

Broemser's model is considerably more sophisticated than Friedman's and probably the best model described in the literature. It seeks to assess the probability distribution of the ratio of the lowest competitor's bid to the analyzing competitor's cost estimate using knowledge of the characteristics of the job itself and knowledge of the past bidding behavior of the competitors. This is accomplished by conceptualizing the low bid price on each job as a product of the cost to do the job and one plus the low mark-up policy.

i.e., low dollar bid = low cost estimate X (1 + low
mark-up policy)

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[46] Broemser, Ibid.

Taking this one step further, the low mark-up policy is interpreted as the sum of the products of important factors and certain weights assigned to them,

$$\text{i.e., low mark-up} = \sum_{k=1}^{N} \underset{\text{low bidder}_k}{(\text{factor weight X factor level}_k)}$$

The assumption is then made that the difference between the analyzing competitor's cost estimate and the low bidder's cost estimate is a random variable independent of the job although perhaps attributable to differing management and planning skills.

This results in:

Low dollar bid = (analyzing competitor's cost estimate
X job independent random variable)
X (summation over factors) (factor weight X factor levels)

Dividing throughout by the analyzing competitor's cost estimate, will give the low bid mark-up as a percentage of the analyzing competitor's cost estimate.

Then:

Incorporating the job independent random variable and the factor weights into a revised factor weight and adding an error term, the result is:

Low mark-up as percent of analyzing competitor's cost estimate = Summation over all relevant factors of

$$\left[\begin{array}{lcl}\text{(revised factor} & & \\ \text{weights i.e.} & & \text{factor} \\ \text{including job} & \times & \text{levels} \\ \text{independent} & & \\ \text{random variable} & & \end{array}\right] + \text{error term}$$

This is the linear regression model form.

(The error term has probability distribution centre at zero and a finite variance σ_e^2 .)

It is assumed that this variance is constant over all jobs and that the factor weights are constant over all jobs.

Next it is necessary to determine which factors are important, what the revised factor weights are and the variance of the error term. Once this is done the probability distribution of the low mark-up bid as a percentage of the analyzing competitor's cost estimate will be described by a mean of: the sum of (factor weights X factor levels) and a variance of: σ_e^2 .

The prior knowledge about bidding a job j will consist of several parts:

(1) Estimated levels of N important job factors

(2) Information from prior bids

From past bids we know low mark-up, as percent of analyzing competitor's cost estimate, and we know the factor levels for each job. From these we estimate factor weights of the low bidder and the variance.

Next:

We assume the error term has a normal distribution with mean 0 and variance σ_e^2.

i.e.

$$\left\{ \underset{\text{error term}}{\varepsilon_j} \Big/ \begin{matrix}\text{Prior}\\ \text{Information}\end{matrix} \right\} \simeq N\left(0, \sigma_e^2\right)$$

then the probability distribution for

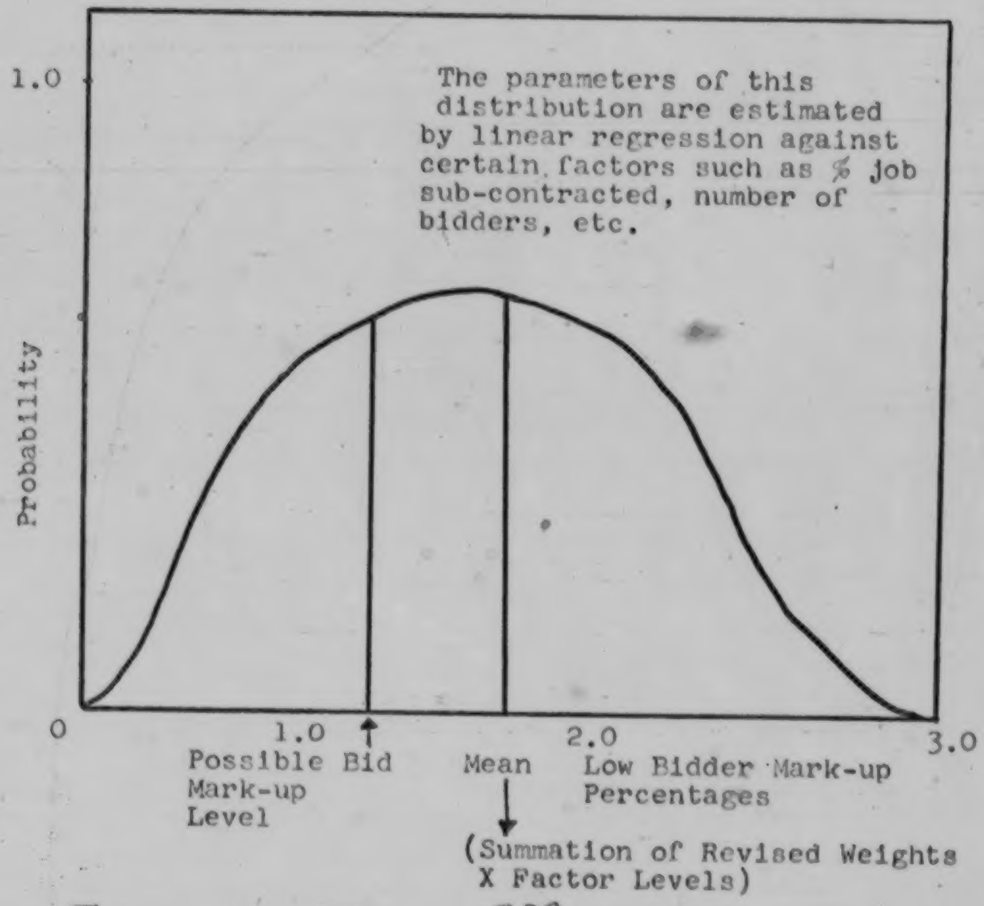
$$\left(\begin{matrix}\text{low percent}\\ \text{mark-up}\end{matrix} \Big/ \begin{matrix}\text{prior}\\ \text{info.}\end{matrix} \right) \simeq N\left(\begin{matrix}\text{Summation of}\\ \text{revised weights,}\\ \text{X factor level}\end{matrix} \sigma_e^2 \right)$$

We then can use linear regression.

When the factor levels of a new job are known the probability of winning with a particular mark-up policy can be calculated as the area under the curve described above, and to the right of the chosen mark-up level.

FIGURE 7

DISTRIBUTION OF LOW BIDDER MARK-UP RATIOS



The parameters of this distribution are estimated by linear regression against certain factors such as % job sub-contracted, number of bidders, etc.

$$P\left[\text{Winning} \Big/ \text{Possible Mark-up Level}\right] = \int_{\text{Possible Mark-up Level}}^{\infty} \left(\frac{\text{Low Bids}}{\text{Analyzing Competitor's Cost}}\right) dx$$

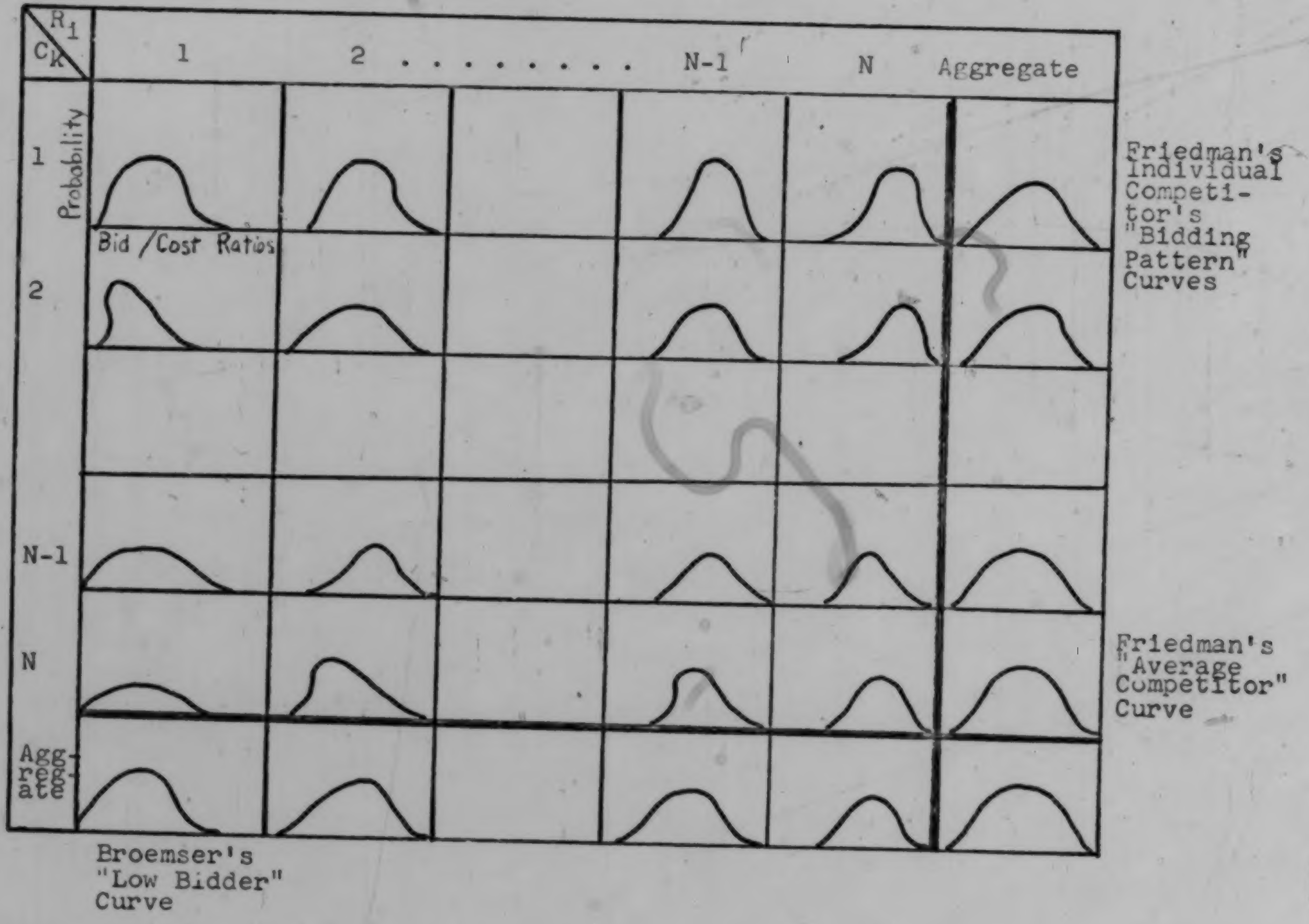
The contrast between Broemser's and Friedman's approaches can be clearly seen in graphical form. On the figure on the next page, is a grid of graphs. Each graph plots curves of the ratios of a competitor's bid price to the analyzing competitor's cost estimate. Each competitor or potential competitor has a number of graphs, each graph plots that competitor's bid price to the analyzing competitor's cost estimate ratio for jobs on which that competitor had some specific rank, i.e., competitor 2 has one graph for all jobs on which he ranked first (i.e., won), another for all jobs on which he ranked second (was second low), etc. The grid is generalized to N ranks and M competitors. The last row and column represent the summation of graphs for that particular row or column.

Note that as the rank increases the mean mark-up level increases for each competitor. It would, however, be conceivable that certain competitors could have a mean mark-up level on their second ranking jobs that was less than another competitor's mean mark-up on first ranking jobs. This is because not all competitors bid every job. Similarly, as one reads down the column of first rank or "won" jobs, it will be noted that certain competitors may have significantly higher mean mark-up levels. This could be due to highly selective bidding.

Consider the last graph in each row. It consists of the summation of all the other graphs in the row, that is,

FIGURE 8

COMPARISON OF FRIEDMAN AND BROEMSER APPROACHES TO WIN PROBABILITY DETERMINATION


R_1
C_K
1
2 . . . .
N-1
N
Aggregate
1
2
N-1
N
Agg-reg-ate
Probability
Bid /Cost Ratios
Friedman's Individual Competi-tor's "Bidding Pattern" Curves
Friedman's "Average Competitor" Curve
Broemser's "Low Bidder" Curve

it contains the competitor bid to analyzing competitor's cost ratios for that particular competitor over all jobs bid regardless of rank. This is Friedman's individual competitor's "bidding pattern" curve. Now consider the graph in the last column and last row of the grid. This graph is the summation of the individual competitor bid/cost ratios over all competitors. Friedman called this graph a description of the "average competitor's bidding pattern." Now consider the graph in the last row of the first column. This again is a summation graph reflecting the sum of first ranking (or won) bids over all competitors. It is the parameters of this distribution that Broemser wishes to estimate.

If competitive bid prices are mutually independent, then Friedman's model as presented in his original paper is correct. This, however, is highly unlikely. Broemser found no evidence of this in his research. Lack of independence does not, however, invalidate Friedman's line of reasoning. What is necessary, assuming no independence, is to estimate from prior information the joint probability density function of Friedman's bid/cost ratios. If this is done, the probability of winning with a given bid becomes:

$$P\left[C_1 \text{ wins } / \ B_1\right] =$$

$$\left[\int_{\frac{B_1}{C_1}}^{\infty} d\left(\frac{B_2}{C_1}\right)\right] \left[\int_{\frac{B_1}{C_1}}^{\infty} d\left(\frac{B_2}{C_1}\right)\right] \cdots \left[\int_{\frac{B_1}{C_1}}^{\infty} d\left(\frac{B_{N-1}}{C_1}\right)\right]$$

$$f\left[\frac{B_2}{C_1}, \ \frac{B_3}{C_1}, \ \ldots . \frac{B_{N-1}}{C_1}\right]$$

as recently shown by Rosenshine.[47]

The problem not dealt with by Rosenshine is just what is the best way to estimate the joint probability density function. Broemser's model is in a way a surrogate measure of the joint probability density functions. By estimating the distribution of low bid mark-up policies he avoids the necessity of estimating disttibution for every possible rank and then working back to the first rank. Although Broemser claims reasonable success with his model it seems clear that it could be improved.

A Revised Approach

Broemser's model attempts to predict the parameters of the distribution of low bidder's mark-up levels via a linear regression prediction equation based on data on all low bidders on jobs on which the analyzing competitor bid. Under this method the estimate of parameters of the low bidder mark-up distribution will be based in part on data from previous low bidders who may not be competitors in the bid under consideration.

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[47] Rosenshine, op. cit.

A significantly more accurate estimate may be made if each potential competitor is analyzed separately and the parameters of each potential competitor's low bidding mark-up profile is estimated on the basis of linear regression analysis of important factors, then the "average low bidder profile for a specific job" can be estimated by combining the information comprising the distributions of the competitors likely to bid a specific job.

This would allow incorporation of more information about specific competitors to enter the analysis and would eliminate the influence of information about competitors who are not likely to bid.

See chart of anticipated directional influences of important factors.

The analysis of firm variables as well as job variables is crucial to accurate estimation of win probability. Broemser limits his analysis to a few job variables, attributing the remaining variance to "job independent" variables. This is understandable in that his methodology precludes analysis of

FIGURE 9

ANTICIPATED DIRECTIONAL INFLUENCE OF IMPORTANT FACTORS ON MARK-UP STRATEGY

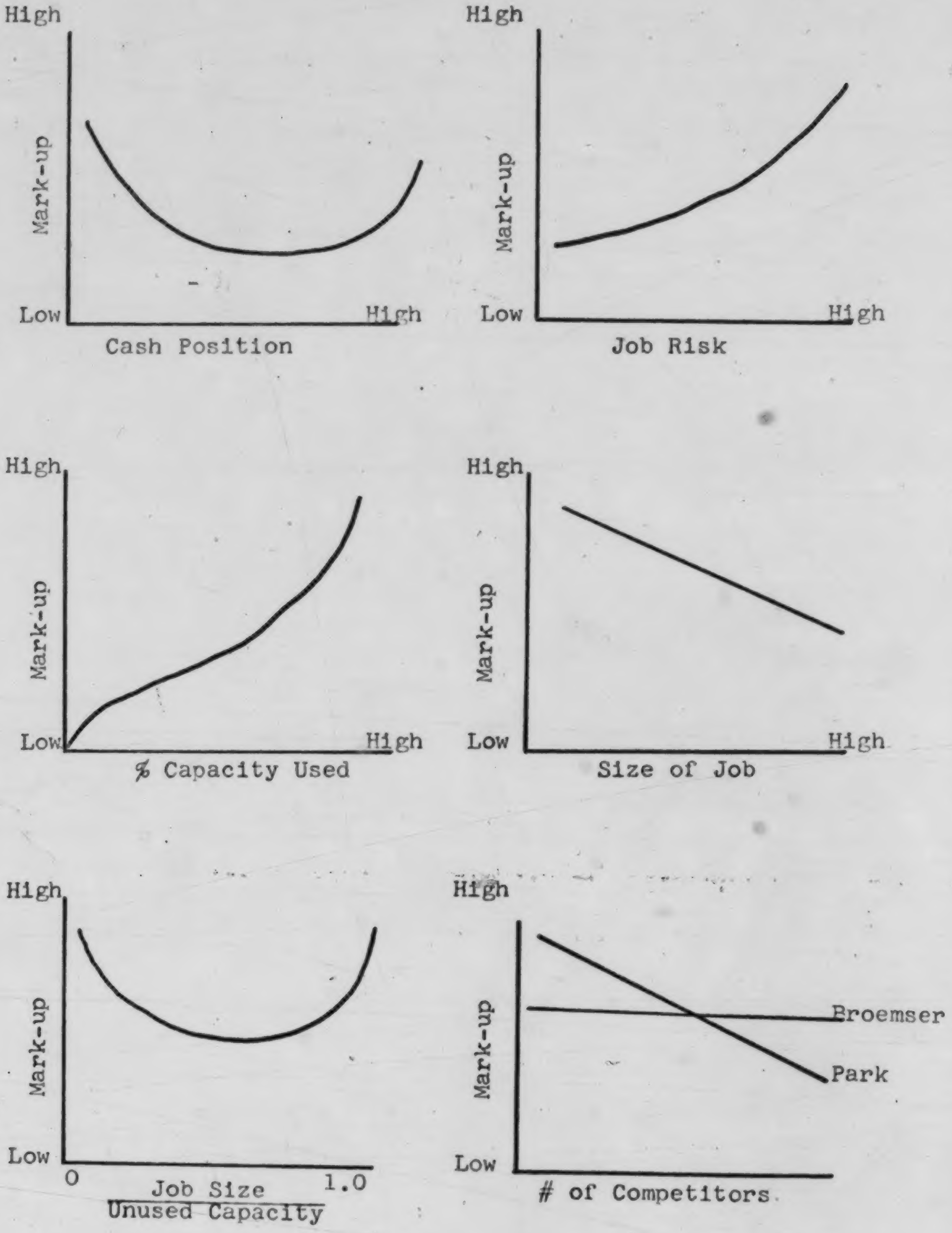
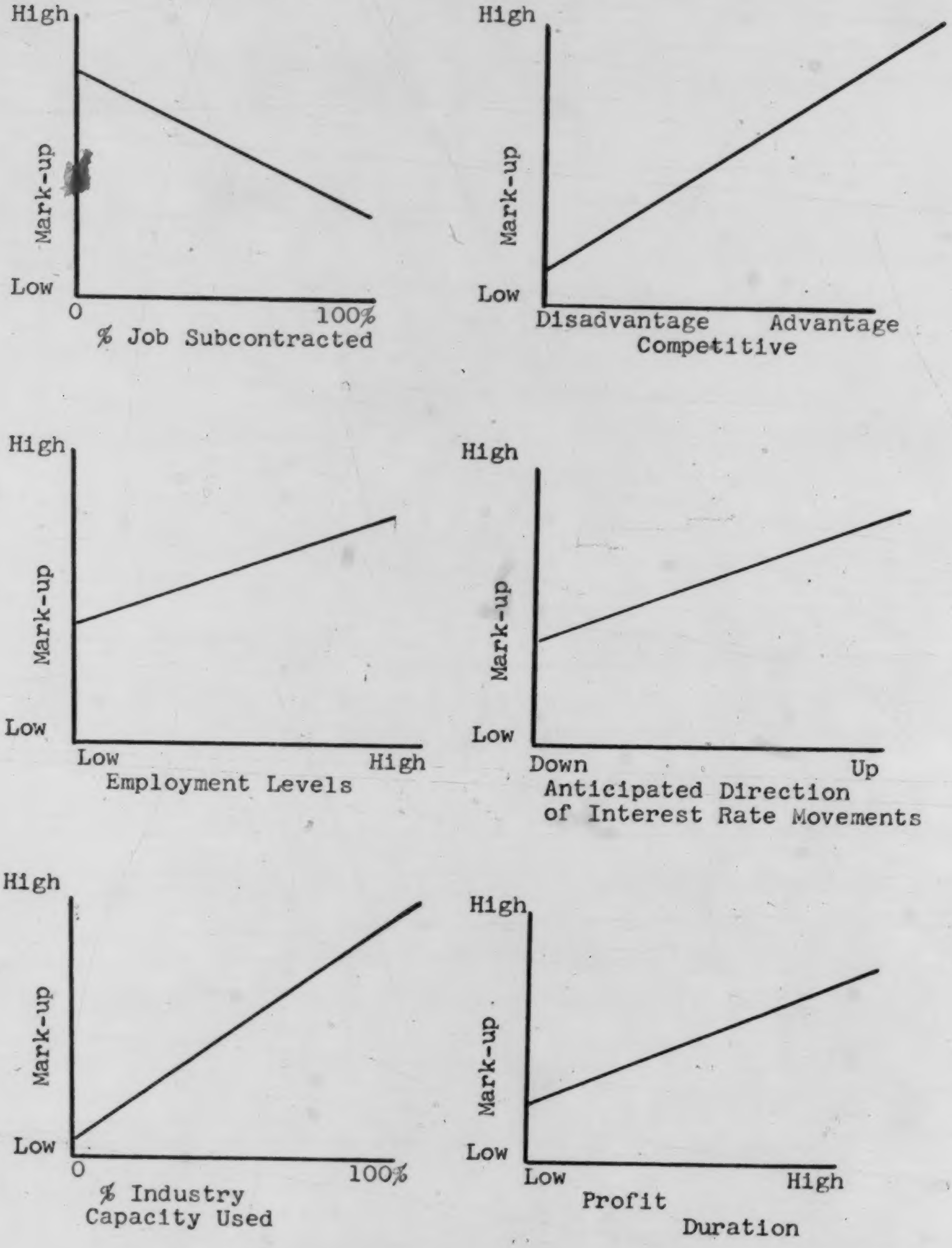


FIGURE 9

ANTICIPATED DIRECTIONAL INFLUENCE OF IMPORTANT FACTORS ON MARK-UP STRATEGY



the individual firms by lumping all low bids into one distribution.

The selection of the important job and firm variables that incluence mark-up policy is the most difficult part of the analysis. One competitor will undoubtedly place a different emphasis on each factor than other competitors. The factors which are important may change from one geographic or product area to another. For example, the important factors which influence mark-up in the building construction segment of the industry may be quite different than those that are significant in, say, heavy construction and road building. Specifically, competitive advantages or disadvantages loom larger in the latter, where construction is usually performed in isolated areas and under arduous circumstances making captive suppliers and the ability to innovate crucial; in building construction, however, the portion of the job subcontracted and the percent of industry capacity unused tend to override other considerations. It is necessary, because of the complex nature of the industry, to decide who one's competitors or potential competitors are and then to do an extensive study of their bidding behavior as it relates to certain factors. A preliminary evaluation of potential competitors' position relative to certain factors may eliminate them from further analysis. If a competitor has a certain bonding capacity and if this capacity is known, it may be possible to eliminate him as a potential competitor by comparing the size of the job to be bid with one's estimation of the competitor's unused bonding capacity. This type of analysis goes far beyond the mere manipulation of past bidding data, extending to the use of credit reporting agencies and all legal means of gaining information about competitors.

The information gathering should be structured and "competitor profile" files kept on all potential competitors. The more information one has the greater is the likelihood for determining an accurate win probability. The bidding files themselves are, however, the prime source of information. Analysis of the past bidding data should yield the most information on relationships between mark-up levels and independent factors.

This section will set forth two methods of analyzing past bidding data. The first deals with the analysis of competitors' bids on jobs which the analyzing competitor has done an engineering cost estimate, the second sets out a method for analyzing all jobs bid by all competitors.

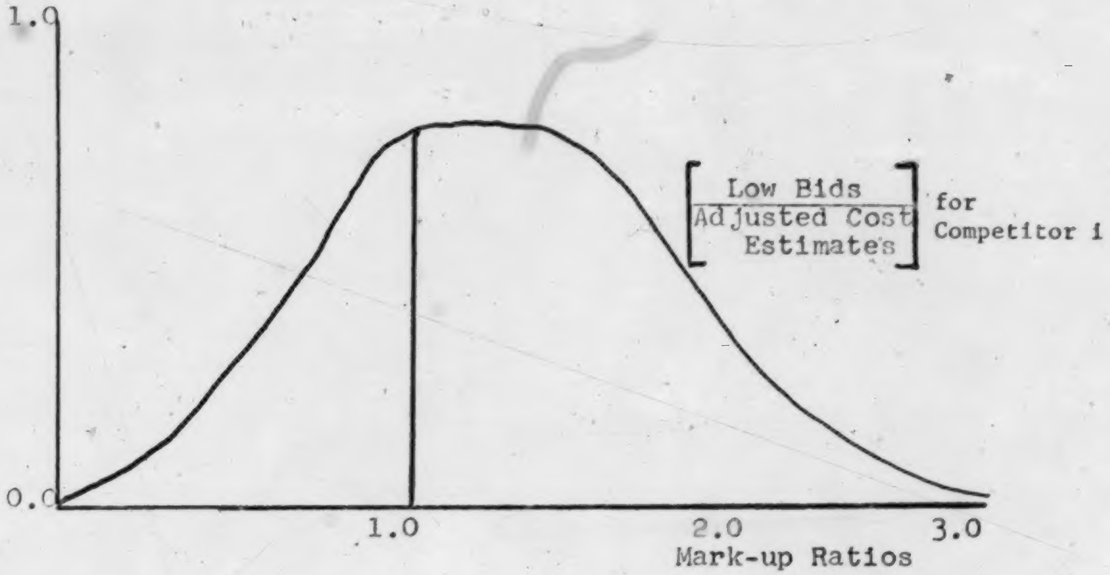
The first step in the analysis of the data will be to determine the distribution of mark-ups for each competitor's low bids on jobs on which we have engineering cost estimates. The mark-up levels are, of course, the $\frac{\text{(low bid)}}{\text{cost}}$ ratios. In order to have an accurate prediction of the competitor's $\frac{\text{bid}}{\text{cost}}$ ratio we must have an estimate of his cost. Most analysts have simply used the analyzing competitor's cost estimate as the denominator of the mark-up ratio. This practice involves two serious omissions. Firstly, the cost estimate should be checked and corrected for bias if any exists. Many contractors use inadequate take-off and costing procedures, often over-costing "to be safe" or "to cover" themselves, and then cannot understand how the competitors can continually win jobs with such "low" mark-ups. The second omission or mistake is the assumption that the analyzing competitor's cost estimate is the best estimate of a competitor's cost estimate. Competitive advantage or disadvantage is a concept recognized by actual contractors and should be recognized in the theory. The accuracy of the mark-up ratio will be increased by adjusting the denominator (analyzing competitor's cost estimate) for each competitor on each job when there are clear advantages or disadvantages involved. This would include adjustments where a competitor is known to have significantly superior or inferior equipment, specialized equipment or knowledge, captive suppliers, etc. It could also extend to important intangibles such as quality of working relationships with the consulting or supervising engineering firms. Adjustments such as the ones suggested here are, to a certain extent, judgmental, but nevertheless should be quantified and used in the analysis.

Once the mark-up ratios of the low bids for a competitor have been adjusted the analysis of the factors which influence mark-up can proceed.

In graphical form what we will have at this point is:

FIGURE 10

PROBABILITY DISTRIBUTION OF MARK-UP RATIOS ADJUSTED FOR ANTICIPATED COST DIFFERENTIALS



The next step is to linear regress against independent factors in order to predict the parameters of the mark-up ratio distribution from which the particular competitor under analysis will select his mark-up for an upcoming job. The pertinent question then becomes what factors should be investigated.

A partial list of factors and their predicted directional influence on mark-up levels appears in Figure 6.

Mark-up Ratio = Function

(1) Job-related variables

- i portion of job sub-contracted
- ii job duration
- iii job duration / estimated cost
- iv no. of competitors
- v size of job (dollars) etc.

(2) Firm-related variables

- i job size / unused capacity
- ii capacity % used
- iii job risk
- iv anticipated direction of interest rate movements
- v cash position etc.

(3) Industry variables

- i expected workload in the industry
- ii employment levels in the industry
- iii current profit levels
- iv number of failures

(4) Economy variables

- i fiscal policy
- ii monetary policy
- iii national employment levels
- iv price levels

If the competitors' bids are independent, then the win probability would have to be determined as in Friedman's analysis, multiplying the areas to the right of the chosen bid level and under the competitors' bid/cost curves. There would be an improvement over Friedman in that the parameters of the mark-up distribution would be related to factors through linear regression and it would be an improvement over Broemser in that the effect of competitors not likely to compete on an upcoming job would be eliminated.

If, on the other hand, competitors' bids are not independent, win probability may have to be determined in a Broemser-like analysis but excluding from the data for each particular job information on low bids relating to a competitor who is not likely to bid.

The analysis of jobs bid by competitors including jobs on which the analyzing competitor has not bid

The approach set forth in this section is designed to permit the inclusion of additional data in the analysis of competitor bidding behavior. Detailed analysis is restricted to low bids of individual competitors, but the requirements that the analyzing competitor must have a cost estimate has been dropped. In the construction industry each competitor bids only a fraction of the total number of jobs offered for tender; therefore, analyzing all jobs which a particular competitor won should reveal additional information on his bidding behavior.

The row data will consist of the bid prices submitted by all competitors on every job which can be considered within the scope of the analyzing competitor's operational market. The analysis proceeds as follows:

Let B_{ij} = Dollar bid of competitor i on job j

$\overline{B_j}$ = Mean of dollar, bids on job j

σ_j^2 = Standard deviation of dollar bids on job j

Z_{lj} = value of low bid on job j.

For each competitor i compute Z_{1j} over all j on which he was low bidder.

Then plot the frequencies of Z_{1j}.

See Figure 11.

Then compute

$$\text{Mean } Z_{lj} = \bar{Z}_{lj} = \frac{\sum_{j=1}^{M} Z_{lj}}{M}$$

$$\text{Variance } Z_{lj} = \sigma_{Z_{lj}}^2$$

$$\sigma_{Z_{lj}}^2 = \frac{B_{ij} - \bar{B}_j}{\sqrt{\sigma_j^2}}$$

$$\bar{B}_j = \frac{\sum_{i=1}^{N} B_{ij}}{N}$$

$$\sigma_j^2 = \frac{\sum_{i=1}^{N} \left(B_{ij} - \bar{B}_j \right)^2}{N - 1}$$

The above graphed distribution will have mean $Z_{1j} = \frac{\sum_{j=1}^{M} Z_{lj}}{M}$

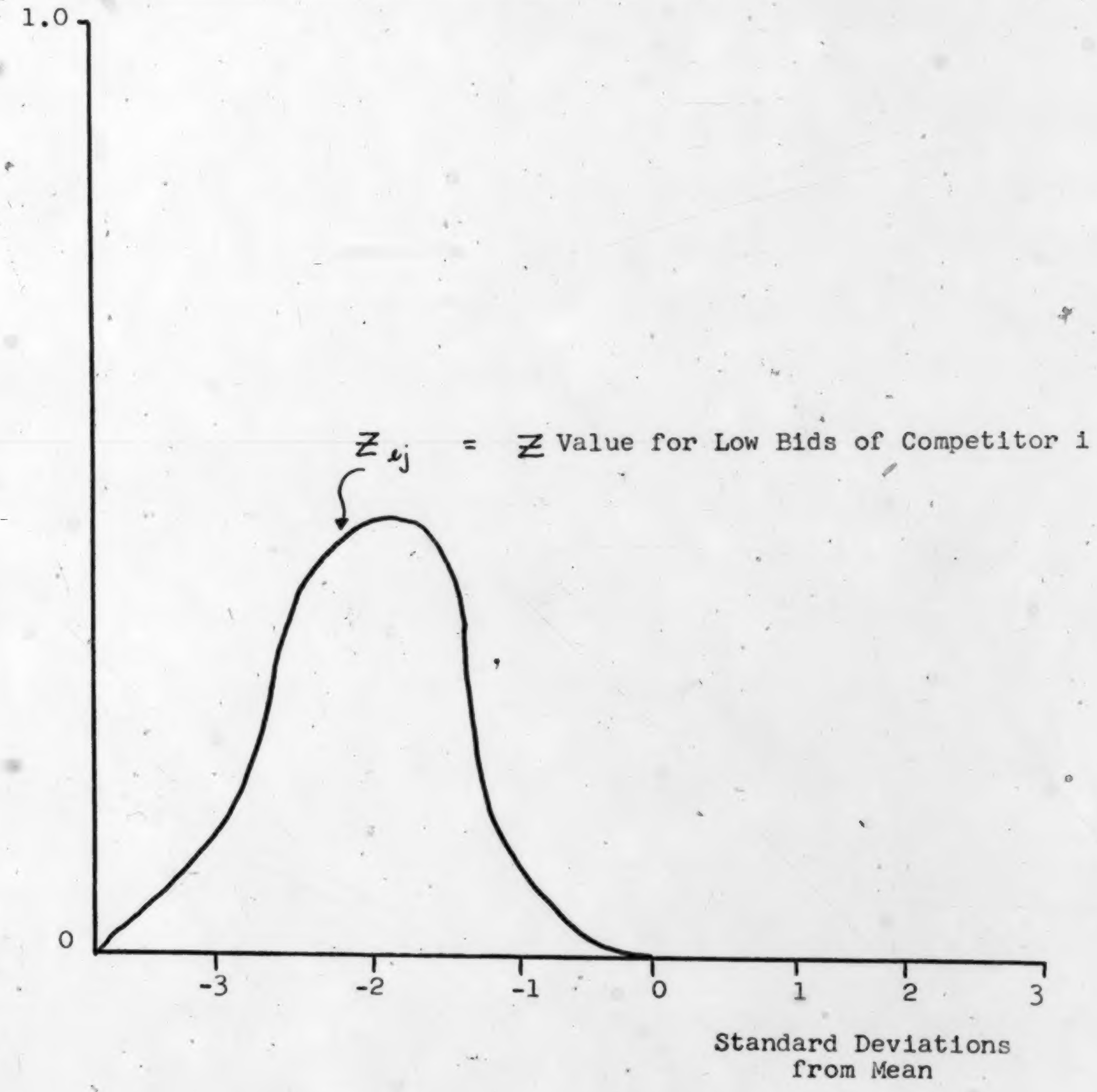
and Variance = $\sigma_{Z_{lj}}^2$

The Z_{1j} represents the numbers of standard deviations below the mean that the low bid lies.

For a particular competitor his bidding behavior on low bids is described as being drawn from a distribution of standard deviations below the mean bid price on these jobs

FIGURE 11

DISTRIBUTION OF VALUES FOR LOW BIDS OF AN INDIVIDUAL COMPETITOR



and this distribution is described by a mean $Z_{\ell j}$,

and a variance of $\sigma^2_{Z_{\ell j}}$.

The parameters of these distributions of low bids could then be estimated by regression against such relevant factors as firm capacity levels at time of bid, distance from firm's head office to job site, estimated cash position of the firm, size of job, and other firm and job related variables.

Once the parameters of these distributions are known, we can pool the information to one low-bid distribution and proceed with a Broemser-type calculation of win probability given an intention to bid at some specific deviation below the estimated mean price on an upcoming job.

The actual dollar amount of a bid would depend on the estimation of the mean bid price on an upcoming job. Through an examination of historical bidding data as it relates to certain important factors such as job size, industry capacity levels and other economic indicators, it should be possible to arrive at a prediction equation for the anticipated mean bid price on jobs. The analysis would, of course, be conceptualized as:

$$\text{Expected mean bid price distribution} = \text{analyzing competitor's expected cost distribution} \; (1 + \text{expected mean mark-up distribution})$$

The scheme outlined above has the advantages of incorporating additional information into the analysis. When the analysis is on the basis of bid/cost ratios, only, jobs for which a cost estimate has been prepared can contribute information, whereas this scheme allows a look at all the low bids of all potential competitors whether or not the analyzing competitor competed with them for the contract. Of course, if there is a situation in which competitors' bids are independent, a Friedman-like treatment of the low bid value distributions could be used to calculate win probability as was suggested in the previous revision.

It is important to recognize that Broemser's method and the two alternate approaches suggested so far are not theories of determining win probabilities but are propositions for improving the accuracy of win probability estimation. There is only one way to determine win probability and it requires complete information which, of course, is never available.

The next section of this chapter discusses a rank order conceptualization of the bidding problem. The improvements suggested above are only a first step toward estimating win probability as outlined below.

The Rank Order Approach to Win Probability Determination

A bidder "wins" if there occurs a rank ordering of the bids submitted in which his bid ranks first. His probability of winning then will be the sum of the probabilities of the individual rank orderings in which he is first occurring. If

N competitors submit bids on any particular job, there are N! possible outcomes or rank orderings, each of which has a probability of occurring between 0 and 1.00, the sum of which probabilities is equal to 1.00 (i.e., one of which is bound to occur.)

Theoretically, the universe with which we are concerned then consists of all potential competitors and their possible bids on an upcoming job. The number of competitors and the amounts they bid are the variables that determine the possible rank orderings of the bids. On any particular upcoming job there may be any number of potential competitors, hence any number of possible ranks.

On the opposing page is a grid of two dimensions, namely competitors and ranks. How then can we determine the probability of each element of the grid, i.e., the probability that competitor 1 ranks first, or second, ... or nth?

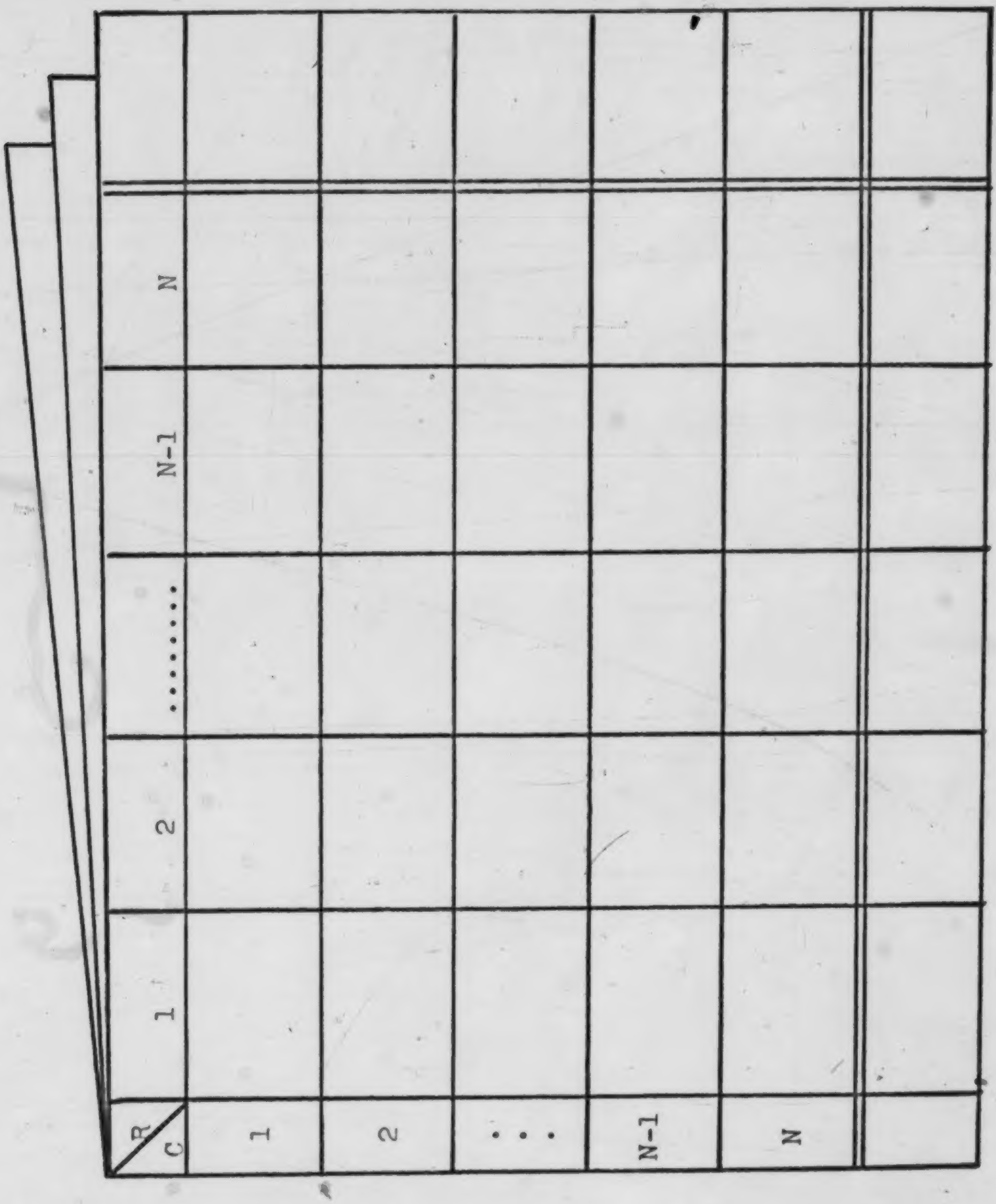
Marvin Gates pondered a special case of this problem and reasoned intuitively that if there were M equal competitors competing on an upcoming job, the probability of each winning should be $\frac{1}{M}$. He then guessed at the following formula for determining win probability:

$$P\,(C_o \text{ wins}) = \cfrac{1}{1 + \cfrac{1-P\,(C_o \text{ beats } C_1)}{P\,(C_o \text{ beats } C_1)} = \cfrac{1-P\,(C_o \text{ beats } C_2)}{P\,(C_o \text{ beats } C_2)} \;\ldots\; \cfrac{1-P\,(C_o \text{ beats } C_{n-1})}{P\,(C_o \text{ beats } C_{n-1})}}$$

when C_o is the analyzing competitor and C_1, C_2 . . . . C_{n-1} represent other competitors. The validity of this formula was recently shown by Rosenshine.

FIGURE 12

GRID ILLUSTRATING FORM FOR COLLECTION OF INFORMATION ON COMPETITOR RANK AND "STATES" OF IMPORTANT VARIABLES ON VARIOUS JOBS



R C	1	2	....	N-1	N	
1						
2						
. . .						
N-1						
N						

A rank order interpretation of this special case arrives at the same result:

If there are N competitors, then there are N! possible rank orderings of their bids. However, each competitor wins only if he is first in the rank order. When one competitor is fixed in the first position there may be (N-1)! arrangements or different rank orderings of the remaining competitors' bids. Thus there are (N-1)! possible rank orders where any particular competitor of N equal competitors can win.

If the competitors are all equal, that is, if each possible rank ordering is as likely as any other rank order, then the probability of any competitor winning can be given as:

$$P\begin{bmatrix}\text{Any one of}\\ \text{N equal}\\ \text{competitors}\\ \text{wins}\end{bmatrix} = \frac{\text{\# of rank orders in which he is first}}{\text{\# of possible rank orders}} = \frac{(N-1)!}{N!} = \frac{(N-1)!}{(N-1)!N} = \frac{1}{N}$$

which is Gates' original conjecture.

The problem arises in that Gates' probability serves only as a description of past bidding behavior. If each of N equal competitors bid as they have on the average in the past, then the probability before the analyzing competitor fixes a mark-up strategy is $^1/_N$. Obviously, since a particular mark-up strategy is entirely within the control of the analyzing competitor, he can change his probability of winning by consciously choosing a particular strategy. Broemser and Friedman give prescriptive models that guide the bidding manager according to his mark-up level; the formula given by Gates serves only as a description of overall bidding behavior.

The rank order theory of win probability determination can also provide information regarding the change in probability of winning as mark-up strategies are changed. If we place within the framework of the previous grid a series of graphs having Probability as the vertical axis and mark-up ratios on the horizontal axis, we will be able to see the effect on probability of ranks as mark-up ratios change (see Figure 13).

The ranks will, of course, depend on how many competitors bid and what the bid prices are. In general, neither of these factors are known prior to bid closing.

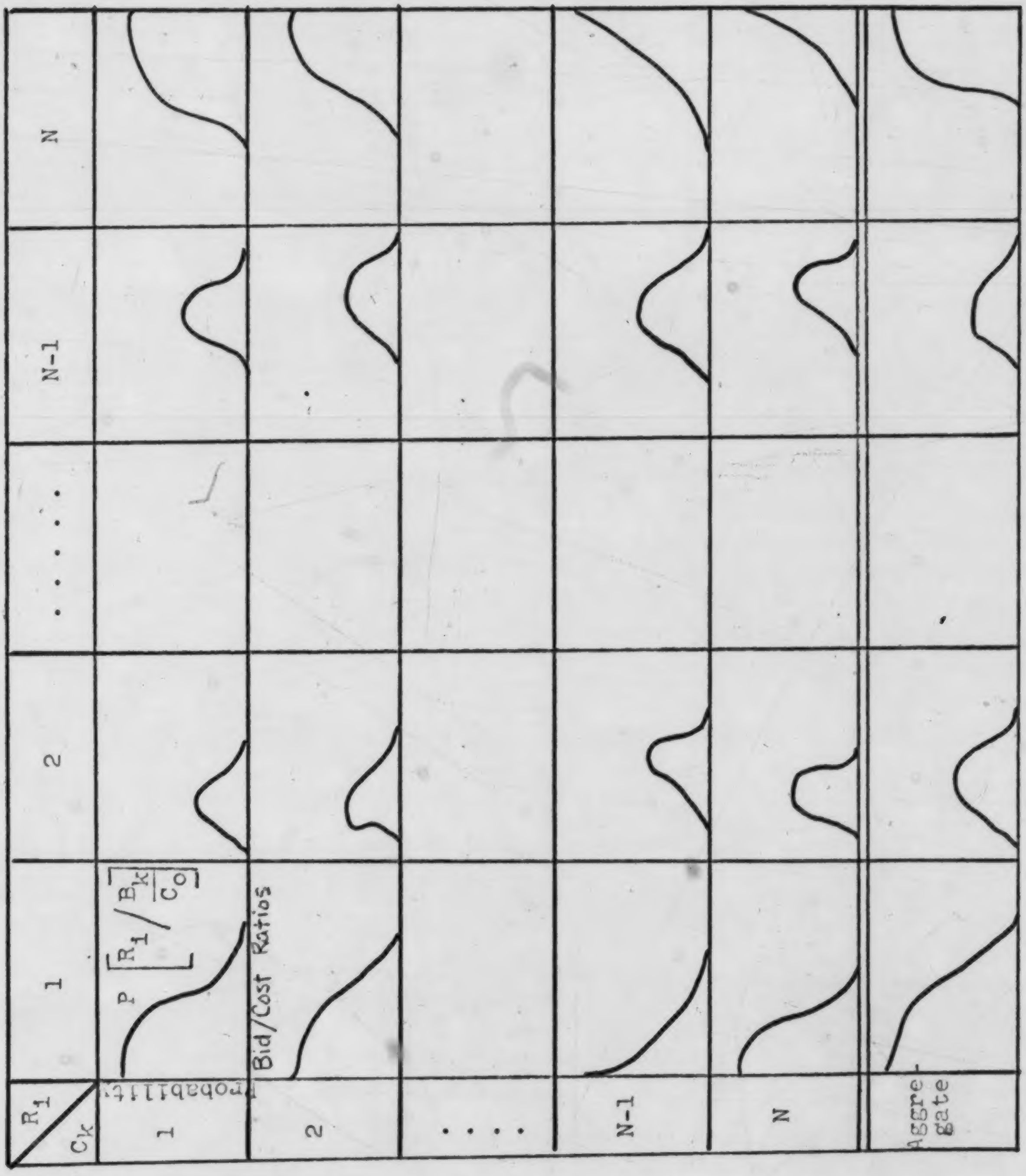
The problem, then, is two-fold--to estimate who the competitors will be and the probability of the analyzing competitor ranking first. To determine the probability of the analyzing competitor ranking first we must determine all rank orders in which the analyzing competitor is first and their individual probabilities. Then we must sum these probabilities. The rank orders will in turn be determined by the bid prices submitted by the competitors.

Conceptually, each competitor's bid price will be his estimated cost multiplied by his chosen mark-up ratio.

If we can accurately estimate each competitor's identity, estimated cost and mark-up ratio, then we can bid just under our lowest competitor's cost X mark-up and secure the job

FIGURE 13

GRID ILLUSTRATING PROBABILITY OF RANK
WITH VARIOUS BID/COST RATIOS FOR EACH COMPETITOR



at the highest possible profit.

The competitors' identities are often known in Canada prior to job closing and generally can be found out even if their names are not published.

It is reasonable to assume that each competitor estimates his costs independently of the other competitors. It is not reasonable, however, to assume that competitors' costs are identical at any level including that of the analyzing competitor. Each competitor's estimated costs should themselves be estimated by the analyzing competitor by means of inputing his (the analyzing competitor's) cost as a rough estimate to be adjusted for each competitor according to known or knowable competitive advantages or disadvantages. An Edelman-like approach incorporating estimation of intangibles may prove helpful here. The estimation of competitors' estimated costs should, of course, include a measure of dispersion and not be a point estimate.

The analyzing competitor's estimation of competitors' chosen mark-up ratios should be an estimation of the probability distribution of mark-up strategies from which each competitor will choose his mark-up ratio (strategy) for a particular job. These probabilities are not necessarily independent as between competitors. They may vary according to the set of competitors anticipated by each competitor. It seems reasonable to assume that since we are attempting to model our choice of a mark-up strategy depending on our anticipation of our competitors' identity, costs and mark-up, some of our competitors may hold a similar approach, however crude.

Because there is uncertainty about the number of competitors and their bids (the necessary determinants of rank order) it is necessary to estimate the joint probability density functions of mark-up strategies for each set of possible competitors, combine this information with the estimates of competitors' cost estimates and determine the bid price probability distributions for each set of possible competitors. With this information in hand, we must then determine the probabilities of the possible rank orderings and sum the probabilities of rank orderings in which the analyzing competitor ranks first, given any particular mark-up strategy. We will then have the win probabilities for any given set of possible competitors and any particular mark-up strategy on the part of the analyzing competitor. Since only one set of competitors will actually compete, there will be a probability of each set of competitors occurring between 0 and 1.0 and since one set of competitors is bound to compete, the sum of the probabilities of the possible sets of competitors will be equal to 1.0. Since the win probabilities for the analyzing competitor are all in the range 0 to 1.0 for any given level of mark-up strategy, the probability of winning the job with a particular mark-up strategy can then be calculated as the sum of the products of the probability of a certain set of competitors occurring and the probability of the analyzing competitor winning (given that set of competitors) summed over all possible sets of competitors, and will be in the range 0 to 1.0.

This conception of the determination of win probability is the only correct one. Any other methods or models presented to date regardless of how effective or practical can only be surrogate measures of the above conception of win probability determination. With this knowledge we must in future examine the models given with the aim of improving their predictive abilities and perhaps combining the best features of many of them into new models directed more to the point. Such measures are beyond the scope of this thesis, but a general approach to management of the information gathered is presented below.

The universe of raw data consists of an identification of each competitor and the price he bids on each job. We can define (delimit) our universe in terms of a multi-dimensional market "grid." Some of the logical dimensions would be scope of geographic activity, product or "nature of job," size of job in absolute amount, etc.

On an information sheet pertaining to each particular job, note should be made of the state "or level" of relevant factors at the time of bidding of the job. Information on job, firm, industry and economy variables should be recorded.

Such information sheets should be kept on every job called that is within the analyzing competitor's "market" or the market of a frequent competitor. When a new job N + 1 is called, we wish to estimate the probabilities of the possible rank orders given each possible set of competitors within our defined "competitive universe." We also wish to estimate the probability of each particular set of competitors competing.

If each information sheet has recorded on it the "state of the world" of as many explanatory variables as seem logical, the task of estimating "win probability" will be potentially more successful. We will know prior to bidding time the "state of the world" as regards certain factors or variables relating to the bid. By comparing the levels or "states" of certain variables, relating to the job to be bid with competitors' bidding behavior on past bids when these factors of variables were in similar "states," we may be able to further limit the range of likely bid prices on the upcoming job. In its simplest form, such an analysis would point out that certain competitors had "no-bid" entries on jobs of a size comparable to the job to be bid, or it would indicate that although a particular competitor often bid against the analyzing competitor he did not bid on jobs of the particular nature of the upcoming one. In a more advanced form such analysis would ideally show the relationship between as many variables as possible (at various levels) and the estimated mark-up strategy of our competitors.

The challenge is to discover, for each particular set of probable competitors, the appropriate weight to assign to the different sources of information we have at our disposal.

For instance, what relative weight should be assigned to historical data on exactly the set of anticipated competitors versus data on a set of competitors near but not identical to the contemplated set? To what extent should we let data influence our evaluations when that data has been accumulated over time--time in which methods, machinery or materials may have changed the nature of a particular job drastically? To what extent should be consider data on a contractor's mark-up behavior on all jobs when, in fact, he is bidding a job of one particular size and nature?

These are problems of design and implementation of an adequate model to describe the competitive environment but not of what that model should seek to do. The theory is clear.

Improved models must draw from Broemser in that they must seek to relate bidding behavior to variables in the competitive environment but they must be much more comprehensive. They must also draw from Friedman in that the analysis must be on an individual competitor basis as well as Broemser's group approach. Low bidders are not a species that behave in a certain way. Today's low bidder may not compete tomorrow or may alter his strategy drastically. We must study the bidding situation as a whole for there may be much information about strategy and attitudes in unsuccessful bids.

The rank order theory of win probability determination provides the conceptual framework within which improvements in the predictive ability of win probability assessment models must take place.

If we consider the data collected on each job information sheet as relevant measurement of the "state of the world" with regard to various dimensions of the bidding environment, the next step in the analysis is to decide just what manipulations of the data will yield the information which will best help us in predicting win probabilities.

The problem with data like that in Figure 12 is that not all competitors C_1 to C_n compete on every job; therefore the ranks R_1 to R_n will not always contain information. Such an organization of data will, however, provide some information on the a priori win probability (probability before the particular mark-up strategy is chosen) of each competitor. It may be possible then to organize the data or rather subsets of the data relating competitions between particular likely sets of competitors to certain known "states of the world" and subsequently using come sort of weighted average of a priori win probability and win probabilities against each particular probable set of competitors.

Even with the likely increases in the accuracy of win probability assessment that may come from a proper conception of the problem, competitive bid pricing models will, in themselves, remain inadequate decision makers. The whole role of competitive pricing models as they relate to corporate strategy and bidding managers is examined in the next chapter.

CHAPTER VI

THE ROLE OF ECONOMETRIC MODELS AND MANAGEMENT INPUTS IN COMPETITIVE BID PRICING DECISIONS

It is crucial to remember that econometric models are a tool of management, not a substitute for management. In competitive bid pricing, models can be a valuable aid to management but are, by themselves, inadequate decision makers. The complexity of the bidding environment requires a rigorous methodology if there is to be any worthwhile analysis. It is here that models fill an important role, providing the means of collecting and organizing large amounts of information and processing this information into easy to interpret formats for management.

The emphasis in the literature to date has been on making the bid price decision by means of a model incorporating a win probability determination and the maximization of a very simple objective function--almost invariably expected profit. Franz Edelman recognized that it may be costly to bid a job and not get it and he therefore included a regret criterion, or cost of not getting the job, in his objective function.[48] Friedman acknowledged the problem of simultaneous bidding on more than one job in his original article (1956) but restricted himself to the maximization of expected profit as an objective function.

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[48] Edelman, op. cit.

Broemser (1968) discusses sequential bidding and the problems of short and long run considerations, but he too settles for the maximization of expected profit. In light of the variety and multiplicity of potential objectives discussed earlier,[49] the models created to date seem inordinately narrow in scope.

The maximization of expected profit alone is not the objective of modern corporate strategy. The firm using a bidding-pricing model must be aware of its limitations as well as its advantages, and the final bid price decision must always rest with management. At any given time the expected profit criterion or an expected profit and regret criterion may be subjugated to other company goals. Cash flow, employment levels, reputations, likelihood of future invitations to bid, market share and competitors' strategic posture are all factors which severally or jointly may logically influence the bid price, but which are in no way quantified in existing models and some of which defy quantification. In addition to consideration of factors other than expected profit, an intelligent approach to bid analysis will examine the value of the expected profit criterion per se.

Expected profit as a goal for maximization in bid pricing has a number of inadequacies. The most obvious is its lack of consideration of time. The appropriate time horizon for maximization of expected profit is an important consideration. Should it be the life of the company, ten years, five years, one year or merely on a job to job basis? Depending on the time horizon chosen certain costs may or may not be regarded as fixed or sunk costs or as variable costs. In the long run, plant, equipment and capacity are variable, but over the short term these are fixed. Another area in which expected value ignores the effect of time is the duration to completion and collection period for a contract. (Two contracts of the same dollar value with identical expected profits may have very different durations either because of the rules of payment and holdback as set out in the contract documents or because of differing natures of the construction requirements, or both. One may involve the installation of expensive, high mark-up equipment and therefore take little time, whereas the other may consist of time consuming, labor intensive work.)

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[49] See ch. III, "The Strategy of Bidding."

The time element in this context is one of the most important determinants of a contractor's profit. It is very similar to cash management within a project, the object being to generate the maximum cash flow as early as possible for each unit of resource commitment to a project. In this case the object is to maximize a composite measure of discounted dollar mark-up per unit of resource commitment over all jobs bid. The expected value criterion is also unable to distinguish between jobs of equal expected value and equal expected discounted dollar mark-up per unit of resource commitment but varying in risk. This problem could be overcome by abandoning the traditional point estimates of costs and opting to estimate probability distributions for costs that take into account the uncertain nature of certain elements of the contract such as soil or water conditions and price level changes. There are, however, a number of criticisms that apply not only to models with the maximization of expected profit as their objective but to all of the competitive bidding models extant.

The inability of existing models to discern the implications of the opportunity cost concept as it relates to corporate strategy is the major reason for retaining the bid pricing decision in the hands of management. The use of the bid price which maximizes expected profit on a particular job may not be consistent with corporate long term goals (expanded market share, etc.) and may not even lead to maximized expected total profit. When two or more jobs are to be bid simultaneously (or for all practical purposes simultaneously), and if these jobs are likely to use or exceed the analyzing competitor's unused capacity, it is questionable as to whether the jobs with the highest expected value should be bid at the price which results in highest expected value, not bid at all, or bid higher than the price at which expected value for that job is maximized. Full capacity at highest expected value available at one particular time is not necessarily the best strategy available. It is entirely possible that mark-up levels will change in the near future and that securing full capacity now may mean that the contractor will be forced to perform low mark-up work and watch his competitors secure the "gravy" jobs. This whole process could of course work in reverse, with the contractor wanting to reach full capacity before mark-up levels fall. This is especially true in Canada due to the pronounced seasonal fluctuations in construction work. It is in this sense that existing models fail to adequately consider opportunity costs.

Another criticism of models in general is their failure to consider the dynamic nature of the bidding process. Each time a contractor competes for a job by competitive bidding he provides his competitors with a piece of information relevant to his competitive position. It should not be surprising that some competitors bid certain jobs under certain circumstances to confuse other competitors. This is usually done only by bidding excessively high and not getting the job, presumably to indicate distinterest or a capacity level above which diminishing marginal returns prevail. The modelling approaches are not capable of considering an opponent's strategy or an opponent's reaction to an analyzing competitor's strategy. The reaction of industry mark-up levels to the prolonged use of bid pricing models by some or all of the competitors is at this time a complete unknown. Until models are developed which can take reasonable account of corporate strategic considerations and until such models have been tested for their effect on mark-up levels and efficacy in maintaining adequate work loads for their users, competitors who use quantitative bid pricing models are on very uncertain ground.

The Use of Models

If the state of the art of modelling the competitive bidding situation is so much in its infancy, what can be gained from the employment of models? What should models do for management and to what extent should management interact with the models?

A model is only a person's attempt to describe in as rigorous and straight-forward a manner as possible his percention of the relationships and interactions of the elements of the environment in which he operates. The symbols and language of quantitative analysis are efficient tools for communication of our perceptions of relationships evidenced in numbers. We seek evidence that our perceptions are correct by examining other people's numerical interpretation of the same events (such as a bid to do a job). In some very simple cases our quantitative language is fully adequate to describe a particular environment with very few parameters. As we attempt to describe more complex environments, we find that our quantitative language is strained to accommodate the multiple considerations. Often we perceive relationships in which there is no consensus on the numerical interpretation, for example, the attitude of different decision makers toward strategy considerations. Nowhere will we find access to a competitor's numerical interpretation of his own attitudes. This does not mean that there is no information on such elements of the competitive environment.

The quantitative model should serve firstly as a summary description of perceptions of relationships and interactions of elements within the competitive bidding environment for which there are readily available quantitative indicators.

The model should, in other words, be designed to sift through empirical data and cull from it estimates of our and our competitors' perceptions of the relationships and interaction of elements within the competitive environment leading to an estimate of win probability at a given mark-up level.

The second function of a model or the second part of a model should be the quantification (in the sense of describing in as rigorous and straight-forward a manner as possible) by the analyzing competitor of his competitor's attitudes toward non-monetary competitive factors. Such factors would include attitude toward reputation, supervising engineers, opportunity costs, and strategy considerations (varying market share, workload, etc.).

The decision on what price to bid can be made by a model only if the model is of adequate scope in what is referred to above as its second function. The bidding manager should be a part of the model by carefully describing his perceptions of competitors' attitudes toward intangibles and strategy considerations and then choosing the bid price in lieu of the win probability estimates at various mark-up levels and the potential the contract has for furthering attainment of the corporate objectives.

CHAPTER VII

DIRECTIONS FOR FUTURE RESEARCH

THEORY

(1) Refining Cost Estimates

Virtually all estimators in the construction industry operate on the basis of point estimates. The problem of variability of costs from estimates is often handled by "allowing enough" to "make sure we're covered." This practice distorts the mark-up level over true costs because of the upward bias in cost estimation. Bidding managers often wonder how a competitor can perform a job for such a low price assuming that the competitor has made a mistake in his bid or that the competitor's costs are actually lower than his own. Very seldom is the accuracy of internal cost estimates questioned beyond their arithmetical veracity. There is need for the development of estimating systems that take into account the variability of costs. The costs of a project may depend to varying degrees on the cost of its elements. Certain elements or portions of a job may be critical to the most efficient scheduling of the project; in such a case, delivery times become an important variable determining the cost of the job and any probable variability in delivery times of such items or elements should be reflected in variability of total project costs. Similarly, the probability of using alternate methods of construction or installation should be reflected in the total probable job cost if alternate methods may result in significantly different costs. For example, on a contract to build a lake or river intake for a water supply project, the costs of the project may vary by 50-100% depending on whether installation is done when there is ice on the lake or river and machinery is able to operate freely directly over the work area or done when there are open water conditions requiring expensive barges and underwater equipment. The methods are not always determinable prior to bid time. If the contract is called in the spring while there is still ice, what are the probabilities of getting the job done before the ice disappears? This probability should be estimated, subjectively if necessary, but it should be considered as a source of possible cost variance in making the cost estimate.

Inflation and constantly rising prices are another source of cost estimate variability that must be taken into account by the intelligent bidding analyst. Suppliers will not give firm prices for more than very short periods of time, yet the contractor, if he gets the job, will receive only one fixed price while his costs rise.

All these factors point out the variable nature of construction costs. Research in the area of cost estimating, especially regarding a methodology or system for producing project cost estimates on a probablistic basis should be of high priority with future researchers.

(2) Refining Estimates of Mark-Up Strategy Probability Distribution

Much more empirical work needs to be done to establish the most economical and effective way of estimating win probability. As explained in Chapter V, the effort should be expended in two directions. Firstly, to estimate the probability of any particular set of competitors competing and, secondly, to estimate the probabilities of the analyzing competitor ranking first, given each particular set of competitors. These, of course, are not easy tasks.

The probability of a particular set of competitors competing on any particular job could, perhaps, be estimated by relating past bidding information to such variables as the nature of the job, the size of the job, the estimated unused bonding capacity of a competitor, location of job, certain qualifications or pre-qualification criteria and published or stated intentions of contractors. It is probably possible to define quite clearly the competitive universe within a geographic and product market grid. This universe can then be further subdivided according to the variables mentioned above (size of job, etc.). Empirical research into this area to discover the extent of our predictive ability is necessary before accurate win probability assessment is possible.

The more difficult field of analysis is the estimation of win probability (rank orders in which the analyzing competitor ranks first), given a particular set of competitors. The most serious difficulty likely to be encountered by researchers is the lack of past information on exactly the set of competitors in question. Where we encounter a small universe of competitors that bid often it may be possible to get useful information from a direct tally of wins versus competitions. It is possible, however, that research efforts may be more fruitful if they are firstly directed at uncovering the relationships between mark-up strategies and factors other than the competitive dynamics. For example, if we can discover how changes in some of the major job, firm, industry and economy variables influence a contractor's choice of mark-up strategy, it may make the job of analyzing the competitive factors somewhat easier.

The primary requisite is a comprehensive probablistic approach to the costing of jobs. Job variables could be analyzed from a competitive advantage or disadvantage situation and it is likely that an approach similar to Edelman's for quantifying management judgements about possible differences in competitive posture may be worthwhile. The effect of firm-related variables such as financial liquidity, capacity levels and cash flows on mark-up levels may be clarified by analysis of bid prices in terms of their relation to some measure that would eliminate the effect of job variables. The number of standard deviations below or above the mean bid price related to some of the firm variables mentioned above may eliminate the effect of job-related variables and give a better indication of their effect on choice of mark-up strategies (e.g., higher or lower).

The influence of industry and economy variables on the choice of mark-up strategies may be more likely to show up if an examination of the levels of such variables as industry capacity and employment levels and economic indicators like capital spending levels are related to average mark-ups (mean bid price less analyzing competitor cost) over time.

At each level of analysis, job, firm, industry and economy, there may exist intangible factors that could be considered via a quantification of managerial judgements. The study of all these and perhaps more factors that are likely to influence mark-up levels will result in a clearer picture of how individual competitors react given various levels of "state of the world" variables. It will not, however, provide much information on how competitors will react to different sets of competitors per se.

The likely paucity of information on identical sets of competitors means researchers may have to resort to some sort of Bayesian weighted average of prior information on an individual competitor and his reactions in competition with likely set(s)? of competitors.

(3) Psychological Factors

In the construction industry in particular, the psychological make-up of the bidding manager is likely to influence his choice of mark-up strategies. The large proportion of owner-manager type firms, combined with a general lack of management education in the industry, results in bid pricing decisions being heavily influenced by the owner-manager's subjective pursuit of maximizing his own utility function. In many cases this utility function may have little to do with economic welfare. The astute bidding analyst should recognize that competitor's choice of mark-up strategies may not always be based on totally unemotional considerations. This does not necessarily mean that the influence of non-rational factors or, more accurately, psychological factors cannot bear rational consideration and perhaps a measure of predictability. Research into the effect of psychological factors on bidding managers is necessary for a full understanding of competitors' bidding behaviour and may well serve to reduce uncertainty in the anticipation of competitors' bids.

(4) Multiple-Simultaneous and Sequential Bid Models

The opportunity costs concept, in the sense of allocating scarce resources to multiple-simultaneous bidding opportunities and in the sense of making fullest possible use of capacity over time, bears more study. Although development of reasonably accurate win probabilities is a major step in the study of competitive bidding, it is only a first step toward solving the opportunity costing and capital budgeting problems of the construction industry. The labor intensive nature of the construction industry (and in Canada the severe seasonality of it) makes time extremely important. There is need for development of a model that will, in reducing alternative bid opportunities to a comparable basis, take proper account of the time elements in relation to the resources commitment required by a job. Jobs should be compared in terms of expected profit per unit of resource commitment per unit of time and then should be appropriately discounted to the present point in time. Even then, the problem of opportunity cost in the sense of minimization of unused capacity over time or the maximization of expected profit per unit of resource commitment per unit of time over time remain unsolved.

The accurate assessment of win probability must come first, but once this is done the areas outlined above will lead to the greatest potential profit improvement.

(5) Equilibrium and Stability

When enough work has been done on the analysis of interrelationships of relevant factors within the competitive bidding environment and their effect on competitors' choice of mark-up strategies, the study of competitive econometric bidding models can reach a higher plateau. Once the basic influences on strategy choice are understood, computer simulation and retroactive application of models to empirical data can enable researchers to study the competitive dynamics of the industry. What happens if everyone uses a particular model or if some but not all competitors use the same model to determine bid prices? What happens to *industry* profitability as a result of the use of sophisticated bidding models? Does it vacillate wildly or settle into an equilibrium where firms as a while are better off or worse off? Will the introduction of sophisticated quantitative analysis to bidding result in a more efficient employment of industry resources? These questions are the truly crucial ones for future researchers, but they cannot be studied at all until an understanding of basic economic and attitudinal factors in the bidding environment has been gained.

VEHICLES FOR RESEARCH

The most promising, and to date totally neglected, vehicle for research on competitive bidding and the influence of factors within the competitive environment on contractors' choices of mark-up strategies is computer simulation and bidding games.

A computerized bidding game of adequate scope could provide the controlled environment and compressed time scale to help discern the effect of various factors on bidding behaviour. The compressed time scale may be particularly helpful in generating enough competitive inter-actions of particular sets of competitors to provide some insight on the reactions of certain competitors to the fact that certain other competitors are likely to bid.

The ability to control most facets of the environment while varying one or two inputs would provide a valuable tool for evaluating the effect of individual factors and may provide information for further refinement for the bidding game.

Various econometric bidding models could be tested for their effectiveness and sensitivity to changes in various aspects of the environment. The human input could be easily introduced and study of psychological factors could be undertaken. The effectiveness of models versus people could be compared. Macro-factors such as industry work-load could be easily studied for effect on general mark-up levels and individual mark-up strategies.

Simulation of the bidding situation is a research tool of great potential for uncovering new information on relationships between bidders and their environment and for testing models and relationships already postulated. As more is known about the dynamics of competitive bidding and incorporated into the simulation, it may well serve as a valuable pedagogical aid for construction bidders.

In the eighteen years since the first work on competitive bidding was published, many of the statistical and economical issues have been clarified and some of them solved. Almost all the published material has been prescriptive in nature, seeking ways to choose bid prices for higher profits. No one, however, seems to have asked the participants what they think is important in deciding on their mark-up strategy. It is highly probable that future researchers could make good use of a survey of bidding managers that sought their (the bidding managers') opinions on which factors were relevant in choosing mark-up strategies and what relative weight they would assign to the factors they thought important. Another interesting question would be to seek bidders' opinions on the relevance of historical bidding data and to what extent the age of past data affects their reliance on it.

There are a number of approaches to the analysis of published bid results that can contribute to the limited body of knowledge surrounding competitive bidding. One of the most effective was Broemser's approach of trying to predict the parameters of the distribution of mark-up strategies of low bidders from historical data. Some other approaches have been outlined in Chapter V. A cautionary note is relevant here. Any future researchers concerned with analysis of emperical data should keep in mind the limitations of the relevance of historical data and should not discount the possibility of age-weighting data in their analysis. Often a carefully considered anticipation may be of more benefit than a direct extrapolation of historical data.

APPENDIX

The information in this appendix relates to Chapter II. Statistical notes and methods, definitions of balance sheet and income statement items, general definitions and changes in definitions included here are the same as in the Statistics Canada publications that were used as a basis for the construction of the graphs and tables in Chapter II.[50]

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[50] The publications used were: (1) *Construction in Canada*, and (2) *Corporation Financial Statistics*.

STATISTICAL NOTES

Sources

The statistics presented in this report are based on information received from organizations and individuals paying for the work done and on information received from contractors performing the work.

The data on the value of construction by type of structure is the result of two separate surveys:

(a) The capital expenditures survey which obtains information from business firms, institutions and government-owned enterprises;

(b) the construction survey of government departments which provides much of the remainder.

In both these surveys respondents report their total expenditures on new and repair construction, by type of structure, additional to a breakdown of these totals into value of work done by contract and by own labour force.

The data on labour and materials input are based on the survey of contractors and sub-contractors and on the censuses of mechanical and electrical trade contractors, highway, road, bridge, and non-residential general contractors.

Respondents report volume of work performed and its input components, as well as further data on type of work, labour force, and capital expenditures.

Methods and Coverage

(i) Of the total value of construction shown, about 79.5% was reported in capital spending surveys of business firms, institutions, government enterprises and departments and residential building activity. The remainder is estimated.

A brief outline of the methods employed to make these estimates is given in the following paragraphs. For a more complete description of these methods, see page 24 of the report Private and Public Investment in Canada, Outlook 1973.

To approximate full coverage adjustments are made to the surveyed data to allow for non-reporting firms.

DEFINITIONS

Construction is defined as the creation, renovation, repair and demolition of immobile structures and the alteration of the natural topography of the ground.

Construction activity consists of the output of the construction industry plus the output of construction labour forces in other industries.

The construction industry is defined as the work performed by establishments primarily engaged in construction on a contract basis. Contract construction in the construction industry is executed by general contractors and special trade contractors. This publication reports "Dollar value" of construction work performed (or put in place) for the construction activity in Canada, as estimated on the basis of surveys (see Statistical Notes, Sources). Included is (1) work performed by the construction industry designated as "Contract construction" (Table 2, p. 8) or "Contractors" (Table 8, p. 13) and (2) work performed by construction labour forces in other than the construction industry, designated as "Own account" or "Other construction" (Table 2, p. 8) or "Utilities--Governments--Miscellaneous"(Table 8, p.13).

New construction comprises all new comprises all new work put in place, as well as additions and major renovations, conversions and alterations where either a structural change takes place or the life of an existing asset is extended beyond its normal life expectancy.

Repair construction consists of minor renovations and alterations made to maintain the operating efficiency of the existing structures.

Structures-- The construction value, and the structures that this is broken down into, includes all costs incurred directly or indirectly in the construction of the structure. In the independently recognizable structures the value of all permanently built-in equipment forming an integral part of the structure is included, as well as the cost of site preparation and land improvement. The purchase value of land and existing buildings is excluded.

Labour content--The Labour Series as published in Construction in Canada is intended to reflect the labour content in terms of "value" and "number" of a specific volume of construction. The "value" is gross payroll and the "number" is an estimate of the total number of persons employers, own account and paid workers engaged in construction activity, expressed in terms of equivalent man years.

Materials content is the cost of materials installed portion of the value of work performed. The residual difference between value of work performed and cost of labour and materials is all other costs and profit.

CHANGES IN DEFINITIONS

The major changes in definitions between this and previous years' publications are shown below in tabular form in Statements 7 and 8.

In large part, these changes have arisen out of a continuing review of the consistency of financial information reported on corporate year-end financial statements. For instance, in Table 3 B, the items "Canadian dividends", "Foreign dividends" and "Dividends received" (and credited direct to earned surplus) are now combined as the single income item "Dividends" because many corporations do not make the distinction between Canadian and foreign dividend income in their financial statements, and because it is useful to put all dividends, whether credited on the income statement or the retained earnings statement, in the same location. Other changes in definitions were made so as to facilitate the comparability of Tables 2, 3 A and 3B items.

It will be noted that two profit items were added: "Net profit before direct taxes" and "Net profit before taxes and non-recurring items". These changes were made so as to segregate non-recurring items and provision for direct taxes from the income and expense items where they were previously included. Another item "Charitable donations" is no longer included in Table 3 but is provided in a special statement (see page 223) because of the particular interest expressed in this item, and to afford its presentation as a ratio of "Net profit before taxes and non-recurring items".

STATEMENT 7. Changes in Definitions Between 1966 and 1969
(Table 2, Summary Financial Statistics)

1966, 1967		1968, 1969	
Line No.		Line No.	
	Assets		
04	Receivables (includes amounts due from affiliates)	03	Accounts receivable
06	Due from Shareholders	05	Due from affiliates (includes amounts due from shareholders)
14	Mortgages, investments, loans (excludes sinking funds)	13	Mortgages, investments, loans (includes sinking funds)

Assets cont'd.

16	Other assets (includes sinking funds)	15	Other assets (excludes sinking funds)

Liabilities

19	Loans, deposits, advances (includes amounts due to affiliates--other)	18	Loans, deposits, advances (exludes amounts due to affiliates--other
20	Accounts payable (includes amounts due to affiliates--trade)	19	Accounts payable (excludes amounts due to affiliates--trade)
	Not shown separately	20	Due to affiliates
21 22	Taxes payable Other current liabilities	21	Other current liabilities

Assets

01 Cash . . . .

02 Securities, advances, deposits . .

03 Accounts receivable. . . . .
04 Inventories. . . . .
05 Due from affiliates. . . . .

06 Other current assets . . . .

07 Total current assets . . . .

08 Land . . . .
09 Depreciable assets . . . .
10 Less accumulated depreciation. . .
11 Depreciable assets--Net. . . . . .
12 Depletable assets--Net . . . . . .

13 Mortgages, investments, loans. . .

14 Investment in affiliates . . . . .

15 Other assets . . . .

16 Total assets . . . .

01 Cash

02 Marketable securities
07 Deposits and advances
08 Mortgages (current)

03 Accounts receivable
04 Inventories
06 Due from affiliates

05 Prepaid expenses
09 Other current assets

10 Total current assets

11 Land
14 Total depreciable assets.
15 Less accumulated depreciation
16 Depreciable assets--Net
17 Depletable assets--Net

19 Mortgages
20 Loans and notes receivable
21 Long-term investments

22 Investments in affiliates
23 Advances to affiliates
24 Deferred charges
25 Other assets
27 Total assets

Liabilities

17 Banks loans. . . . .

18 Loans, advances, deposits. . . . .
19 Accounts payable . . . .
20 Due to affiliates. . . . .

21 Other current liabilities. . . . .

22 Total current liabilities. . . . .

23 Deferred income. . . . .
24 Due shareholders or affiliates . .
25 Net long-term debt . . . .

26 Other liabilities. . . . .

27 Total liabilities. . . . .

28 Banks loans
29 Short-term loans
34 Advances and prepayments
30 Accounts payable
35 Due to affiliates
31 Taxes payable
32 Long-term debt due within year
33 Dividends payable
36 Other current liabilities
37 Total current liabilities

38 Deferred income
39 Due shareholders or affiliates
44 Net long-term debt
45 Reserve for future income tax
46 Other liabilities

48 Total liabilities

Equity

28	Common shares	49	Common shares
29	Preferred shares	50	Preferred shares
30	Retained earnings	51	Retained earnings
31	Other surplus	52	Subsidiary profits in surplus
		53	Surplus reserves
		54	Other surplus
32	Total equity	55	Total equity
33	Total liabilities and equity	56	Total liabilities and equity

Revenue

34	Sales--Products	01	Sales--Products
35	Sales--Services	02	Sales--Services
36	Rental income--Real estate	03	Rental income--Real estate
37	Investment income	06	Bond interest
		07	Mortgage interest
		08	Other interest
		09	Dividends
38	Other revenue	04	Rental income--Other
		05	Commissions
		10	Other income
39	Total income	11	Total income

Expenses

40	Materials	12	Materials
41	Salaries and wages	13	Salaries and wages
42	Rent	15	Rent
43	Interest	17	Bond interest
		18	Mortgage interest
		19	Other interest
44	Depreciation	21	Depreciation
45	Depletion and amortization	22	Depletion and amortization
46	Other expenses	14	Repairs and maintenance
		16	Royalties
		20	Taxes other than direct taxes
		23	Other expenses
47	Total expenses	24	Total expenses
48	Net profit before taxes and non recurring items	25	Net profit before taxes and non-recurring items
49	Non-recurring items	26	Non-recurring items

Expenses cont'd

50	Net profit before direct taxes	27	Net profit before direct taxes
51	Provision for direct taxes	28	Provision for income taxes
		29	Mining and logging taxes
52	Net profit (loss) after taxes	30	Net profit (loss) after taxes

Retained earnings

53	Opening balance	31	Opening balance
54	Net profit (loss) after taxes	32	Net profit (loss) after taxes
55	Dividends	33	Cash dividends declared
		34	Stock dividends declared
56	Other charges and credits	35	Other charges and credits
57	Closing balance	36	Closing balance

Cost of sales--Products

58	Sales--Products	37	Sales--Products
59	Less cost of sales	38	Less cost of sales
60	Gross profit	39	Gross profit

DEFINITIONS

TABLE 3 A. DETAILED BALANCE SHEET STATISTICS

Number of Corporations

This is the actual number of corporations in the corporate universe in Canada as assigned to each industry, with the exception of those corporations outlined in Statement 1. The figures shown for the financial items are based on a sample of these corporations, appropriately expanded to represent the industry universe.

Assets

Cash (line 01) includes Canadian and foreign currency, cheques, bank drafts, money orders and bank deposits. Bank overdrafts and outstanding cheques are not deducted from the cash balance, but are included as "Bank loans" in the liabilities section. Cash held in restricted deposits for tenders or contracts is included in "Deposits and advances".

Marketable securities (line 02) include corporation shares, bonds and debentures, Government of Canada bonds and treasury bills, provincial and municipal securities, and all types of negotiable securities valued at cost, which are held as current or temporary portfolio investments. Guarantee certificates and funds, term deposits, finance company and commercial paper, bankers' acceptances and collateral bank deposits are also included.

Accounts receivable (line 03) include amounts billed for merchandise and services and are shown after deductions for doubtful accounts. Trade amounts due from affiliated companies are shown in "Due from affiliates". Loans of some financial organizations such as sales finance and acceptance companies are treated as accounts receivable. Accrued dividends and interest receivable are also included in this item.

Inventories (line 04) include assets acquired for resale in the normal course of business such as raw materials, work in process, and finished goods. Land, buildings, and real estate being developed are classed as inventory when held for resale in the normal course of business. Inventories are shown before deduction for reserves which are placed in "Surplus reserves".

Prepaid expenses (line 05) represent payments made during an accounting period which benefit the next accounting period. Common examples are: prepaid insurance premiums, interest, rent, advertising, travelling advances, and office supplies.

Due from affiliates (line 06) includes trade accounts receivable and other current amounts owed by affiliates with the exception of interest and dividends. Amounts due from shareholders or officers of a corporation are also shown here.

Deposits and advances (line 07) include short-term items such as deposits on contracts, advances to suppliers, loans receivable and call loans of banks and trust companies. Amounts are shown at face value with the exception of the bank and trust companies' call loans which are shown after deductions for reserves.

Mortgages (current) (line 08) refer to the current portion of mortgages receivable.

Other current assets (line 09) consist of current assets not elsewhere included, such as accrued trade receivables, receivables from employees, and automobile dealers' finance participation.

Total current assets (line 10)--The sum of lines 01 to 09 inclusive.

Land (line 11) refers to the acquisition cost or appraised value of land as shown on the company statements. Land improvements which are depreciable are shown with "Equipment and other" while natural resources are included in "Depletable assets--net". Land held for resale in the normal course of business is included in "Inventories".

Buildings (line 12) include improvements to leaseholds and are included at acquisition cost or appraised value as shown on the company statements. Buildings which are to be resold by contractors or real estate developers are shown in "Inventories".

Equipment and other (line 13) includes the installed, or delivered cost, or appraised value, of machinery, furniture, fixtures, vehicles, and engineering structures, such as private roads, railway tracks, power and telephone lines, pipe lines, and depreciable land improvements. Equipment held for resale in the normal course of business is shown in "Inventories".

Total depreciable assets (line 14) are shown before depreciation and equal the sum of lines 12 and 13.

Accumulated depreciation (line 15) is the total of all the annual depreciation charges and amortization of improvements against the depreciable assets.

Depreciable assets--net (line 16)--The difference between line 14 and line 15.

Depletable assets--Net (line 17) include such items as water and power rights, timber limits, leases and rights to oil and gas wells, quarries, and fisheries. Exploration and development expenditures of mines and oil and gas wells capitalized are included. The amounts shown are net after deduction of depletion or amortization.

Total net fixed assets (line 18)--The total of lines 11, 16 and 17.

Mortgages (line 19) refer to the long-term portion of mortgages receivable and agreements for sale shown at face value. Reserves deducted are shown in "Surplus reserves". Mortgages receivable from affiliated companies are shown in "Advances to affiliates".

Loans and notes receivable (line 20) include long-term loans, notes, chattel mortgages and long-term receivables, except from affiliates.

Long-term investments (line 21) include shares and other securities, except those of affiliated companies, held as long-term investments. Investments are at face or market value as shown on the company statements, with reserves for losses included in "Surplus reserves". Cash or securities deposited for special purposes such as sinking funds are also shown here.

Investment in affiliates (line 22) consists of total investment in common and preferred chares of subsidiary and affiliated companies at cost or equity basis as shown on the company statements. In the latter case the share in the subsidiary corporation's accumulated profits or losses is included here and shown separately in the retained earnings section as "Subsidiary profits in surplus". Reserves for losses in the case of corporations reporting investments on a cost basis are included in "Surplus reserves".

Advances to affiliates (line 23) include non-current amounts due from affiliated companies including notes and mortgages. Investments in joint ventures and partnerships are also shown here.

Deferred charges (line 24) include expenditures which are expected to benefit a number of succeeding accounting periods such as: discounts on bond issues, organization expenses and tooling and development expenses. Mining companies often defer some operating expenses until operations reach a normal level.

Other assets (line 25) include non-current items which are not specified elsewhere, such as containers, cash surrender value of life insurance policies, goodwill, trademarks, franchises, livestock and stock exchange seats.

Total other assets (line 26)--The sum of lines 19 to 25 inclusive.

Total assets (line 27) are shown after deduction of accumulated depreciation and equal the sum of lines 10, 18 and 26.

Liabilities

Bank loans (line 28) include bank overdrafts and outstanding cheques as well as current loans from Canadian chartered banks.

Short-term loans (line 29) are those owing to individual share-holders, foreign banks, finance companies, governments and corporations other than affiliates and Canadian chartered banks. Guarantee certificates and funds on deposit in the case of deposit accepting institutions are shown here.

Accounts payable (line 30) include only amounts designated as "trade" accounts payable and "trade" notes payable. Trade amounts owing to affiliated companies are included in "Due to affiliates" (line 35).

Taxes payable (line 31) include all taxes payable by corporations to governments in Canada except sales and excise taxes and employees' income taxes which are listed in "Other current liabilities".

Long-term debt due within year (line 32)refers to the current instalments of sinking funds, mortgages or other long-term debt.

Dividends payable (line 33) represent cash dividends payable and interest payable on income bonds and debentures.

Advances and prepayments (line 34) include amounts received for goods or services which are to be supplied within a year and progress payments and mortgage advances received in the case of contractors.

Due to affiliates (line 35) includes trade accounts payable and other amounts due to affiliated companies except dividends.

Other current liabilities (line 36) include such items as interest payable, foreign taxes payable, employees' income tax, sales taxes, mortgage reserves deducted from current mortgages, and reserves deducted from "Deposits and advances".

Total current liabilities (line 37)--The sum of lines 28 to 36 inclusive.

Deferred income (line 38) refers to all revenues or income received before it is earned, excluding advances and prepayments of a current nature. Examples of items included are: deferred profit on instalment sales, unearned interest or service charges, and unamortized operating subsidies.

Due to shareholders or affiliates (line 39) includes all non-current debt, remuneration or mortgages, due to shareholders or affiliated corporations.

Mortgage debt (line 40) consists of total mortgage debt outstanding on real estate, except that due to affiliates.

Bonds and debentures (line 41) consist of total bond and debenture debt outstanding except that owing to affiliated corporations.

Other long-term debt (line 42) consists of miscellaneous items outstanding such as loans from suppliers, bank loans, and employees' funds deposited as an investment.

Due within one year (line 43) corresponds with "Long-term debt due within year" (line 32) and comprises the current portion of "Mortgage debt", "Bonds and debentures" and "Other long-term debt" which is deducted from the total of these items to arrive at "Net long-term debt" (line 44).

Reserve for future income tax (line 45) represents deferred income taxes that may be payable in the future because of timing differences in accounting for book purposes and for taxation purposes (mainly depreciation versus capital cost allowance).

Other liabilities (line 46) consist of miscellaneous liabilities not included elsewhere such as: reserves for returnable containers, tenants' refundable deposits, pension reserves and other sundry liabilities.

Total non-current liabilities (line 47)--The sum of lines 38, 39, 44, 45 and 46.

Total liabilities (line 48)--The sum of "Total current liabilities" and "Total non-current liabilities", (lines 37 plus 47).

Equity

Common shares (line 49) refer to those classes of shares so designated on the balance sheet. If no designation was made, shares carrying voting rights are included here.

Preferred shares (line 50) refer to those classes of shares so designated on the balance sheet. If no designation was made, shares not carrying voting rights are included here.

Retained earnings (line 51) consist of the accumulated earnings of corporations which are avilable for dividends or other purposes, and is net after deducting accumulated deficits. This item is alternatively called earned surplus, undivided profits and rest account. Included in this category is the head office account in the case of unincorporated Canadian branches of foreign incorporated firms. Retained earnings is equal to the "Closing balance" (line 36) of the Retained Earnings Section.

Subsidiary profits in surplus (line 52) represent accumulated profits (or losses) of subsidiaries which have been included in the surplus of the reporting corporations when the reporting corporations record such profits (or losses) on the "equity basis".

Surplus reserves (line 53) represent amounts appropriated from retained earnings or earned surplus for contingencies such as future declines in inventory or investment values and losses on long-term receivables.

Other surplus (line 54) includes revaluation surplus such as the excess of appraised value of fixed assets over net book value and excess of market value of investments over cost, contributed surplus such as the proceeds of no-par value shares allocated to surplus, and capital surplus arising out of the redemption of preferred shares.

Total equity (line 55)--The sum of lines 49 to 54 inclusive.

Total liabilities and equity (line 56)--The sum of lines 48 and 55.

TABLE 3 B. DETAILED INCOME AND RETAINED EARNINGS STATISTICS

Income

Sales--Products (line 01) represent the amount of revenue resulting from sales, other than services, after deducting sales and excise taxes, discounts, rebates, refunds, and subcontracts. Freight out is included when it represents part of the purchase price. The cost of sales and gross profit on sales of products are shown on lines 38 and 39, respectively.

Sales--Services (line 02) consist of income from the sale of such services as transportation, storage, repairs, and management. This item is shown after deducting discounts, refunds and sales taxes. No cost of sales is recorded for this item.

Rental income--Real estate (line 03) is the gross amount received from the rent of apartments, offices, factories, houses, land etc. Income from the leasing of natural resources such as oil rights is included in "Other income".

Rental income--Other (line 04) includes income from the rental of machinery and equipment, ships, films, and from the rental of hotel, motel and tourist rooms.

Commissions (line 05) consist of revenue earned by corporations when acting as agents in the selling or buying of goods or services. Corporations which have commission income include financial institutions, stockbrokers, real estate agencies, advertising agencies, and grain dealers.

Bond interest (line 06) includes interest and premium income earned on treasury bills and investment certificates as well as on bonds and debentures. In the case of foreign issues interest is shown net of foreign withholding taxes.

Mortgage interest (line 07) consists of gross interest earned from Canadian mortgages on real estate.

Other interest (line 08) includes gross interest earned on bank accounts, chattel mortgages, accounts receivable, loans and notes receivable.

Dividends (line 09) include all cash or stock dividend income earned whether credited to income or surplus accounts on the company statements. In the case of foreign issues dividends are shown net of foreign withholding taxes.

Other income (line 10) includes sundry income not specified elsewhere such as: royalties received, recovery of shared expenses, and subventions received.

Total income (line 11)--The sum of lines 01 to 10 inclusive: it should be noted that capital gains are included in "Non-recurring items" (line 26).

Expenses

Materials (line 12) consist of the costs of goods purchased and resold, including freight in, and purchased items included in cost of sales such as raw materials, manufacturing supplies, insurance, fuel, light and power, but excluding repairs and maintenance. Where the financial statements do not show a breakdown of cost of sales by object (notably in the extractive industries), this item may include such costs as direct labour, depletion and depreciation, and overhead expenses included in cost of production.

Salaries and wages (line 13) represent the total expense of salaries, wages, fees and bonuses paid to the employees, officers, and directors of corporations. Employee benefits such as group insurance, pensions, workmen's compensation and unemployment insurance are not included here but are shown in "Other expenses".

Repairs and maintenance (line 14) include the expense of repairs to fixed assets. Salaries and wages are exluded where identified and included above.

Rent (line 15) consists of rent expense for land, and buildings.

Royalties (line 16) represent the cost of rights to use natural resources such as oil and gas reserves, ore bodies and timber limits and intangible property such as copyrights, franchises, patents and performing rights.

Bond interest (line 17) consists of interest and discount expense paid on debentures and mortgage bonds, guaranteed trust certificates and investment certificates.

Mortgage interest (line 18) is the interest and discount expense on real estate mortgages only.

Other interest (line 19) includes interest and discount expense on bank loans, accounts payable, chattel mortgages, loans and notes payable.

Taxes other than direct taxes (line 20) include such items as municipal taxes, business taxes, water taxes and motor vehicle and beverage licences. Income taxes, provincial mining and logging taxes, and sales and excise taxes are excluded.

Depreciation (line 21)--This item represents the proportion of the cost of basic value of tangible fixed assets charged to the current year for book purposes. The methods used by corporations for determining this item may differ substantially from the methods prescribed by Income Tax Regulation for the calculation of Capital Cost Allowance.

Depletion and amortization (line 22) represent the total current write-off or amortization of the cost of acquisition and development of natural resources such as timber limits, ore bodies, oil and gas reserves.

Other expenses (line 23) include expenses not elsewhere specified such as office supplies, provisions for bad debts, charitable donations, management fees, advertising costs, travelling expenses, portion of shared expenses, workmen's compensation, pensions, unemployment insurance and group insurance costs.

Total expenses (line 24) is the sum of lines 12 to 23 inclusive. It should be noted that provincial mining and logging taxes, income taxes, and capital losses are included below.

Net profit before taxes and non-recurring items (line 25) is calculated as "Total revenue" (line 11) minus "Total expenses" (line 24) and represents net profit before deduction of direct taxes and non-recurring or extraordinary items.

Non-recurring items (line 26) or extraordinary items, consist of the net of capital gains and losses on the disposal of assets reported by corporations either in their profit and loss statement or schedule of retained earnings.

Net profit before direct taxes (line 27) is equal to line 25 minus line 26.

Provision for income taxes (line 28) consists of provision for Canadian federal and provincial income taxes with respect to the current year's operation. This includes taxes estimated as currently payable and taxes estimated as payable in future years because of timing differences in accounting for book purposes and taxation purposes.

Mining and logging taxes (line 29)--These taxes are levied by provincial governments on income derived from mining and logging operations, and are shown as a provision on the company books.

Net profit (loss) after taxes (line 30) is the net of all book profits and losses reported. It includes non-recurring items and dividends received and is after provision for taxes. This item equals line 27 minus lines 28 and 29.

Retained Earnings

Opening balance (line 31) is the balance of retained earnings at the beginning of the accounting period.

Net profit (loss) after taxes (line 32) is identical to line 30, and is the net of profits credited and losses charged to retained earnings for the year's operation.

Cash dividends declared (line 33) consists of cash dividends declared on common and preferred shares during the fiscal period.

Stock dividends declared (line 34) represents dividends declared in the form of redeemable preferred shares.

Other charges and credits (line 35) include items such as liquidating dividends, prior year adjustments for either profits or taxes, remittances to head office by unincorporated Canadian branches of foreign corporations, dividends paid in the form of common stock, and other charges or credits to retained earnings. (See note on statistical adjustment below.)

Closing balance (line 36) is the year-end balance of retained earnings that is transferred to the equity section of the Balance Sheet (line 30, Table 3 A).

Cost of Sales--Products

Sales--Products (line 37): This line is identical to line 01 above.

Cost of sales (line 38) pertains to sales of products only and in the case of service industries consists of materials as defined above (line 12), direct labour costs and production overhead costs such as plant depreciation, depletion, repairs and maintenance. For the wholesale and retail industries this item consists mainly of goods purchased and resold. For the extractive industries, this item includes costs of mining, milling, concentrating, and drilling.

Gross profit (line 39) equals "Sales--products" (line 37) less "Cost of sales" (line 38) above.

Note--Re statistical adjustment--A statistical adjustment has been included in "Other charges and credits" for the first time in the 1969 data. The purpose of this adjustment is to equate the opening balance of retained earnings for 1969 with the 1968 closing balance. This adjustment reflects discrepancies in the continuity of retained earnings arising from such factors as changes in industrial classification, corporate reorganization, write-offs and residual sampling error.

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